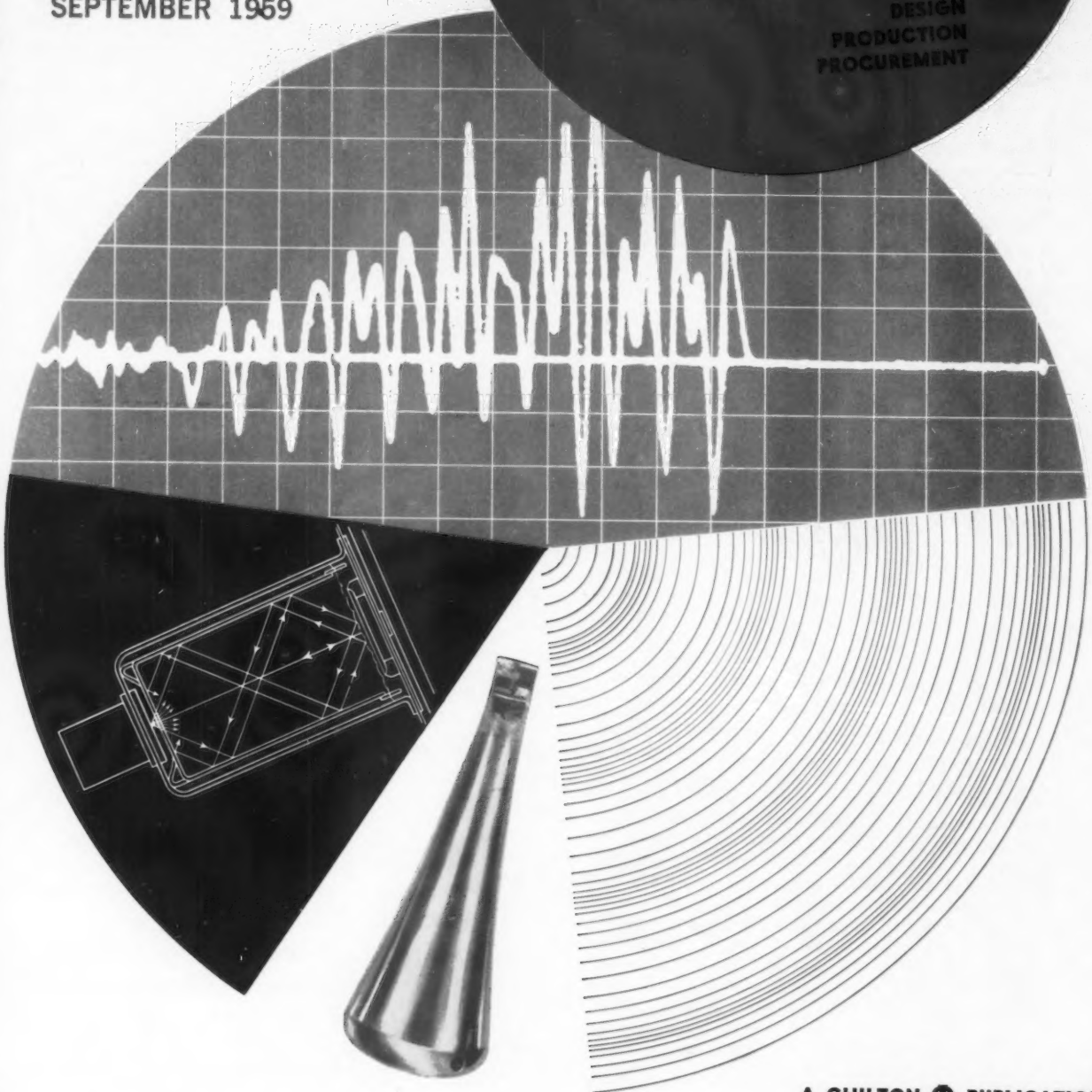
AIRCRAFT AND MISSILES MANUFACTURING

DESIGN
PRODUCTION
PROCUREMENT

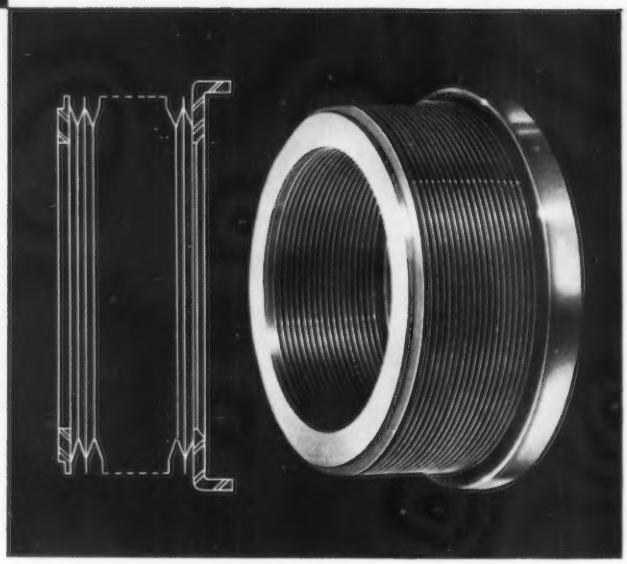
SEPTEMBER 1959



A CHILTON PUBLICATION

C/R DESIGN NOTES

How C/R's New Metal Bellows Seal Meets Seemingly Impossible Operating Conditions



Operating Ranges

Temperature	−400° to 1000° F.
Pressure	500 psi
R.P.M.	80,000 plus

These known operating ranges indicate the function of this seal. It is designed for applications where temperatures and mediums to be sealed forbid the use of any organic materials. Typically, these applications include fuel pumps, compressor power units and turbine starters characteristic in rockets and missiles. Other applications include mechanisms which are exposed to a high level of radioactivity.

Design Advantages

The C/R metal bellows seal consists of a metal bellows — a welded homogeneous unit which is secured at one end — and a carrier ring in which the sealing face is mounted. The seal does not contact the shaft. It is stationary, and the only rubbing surfaces are the sealing face and mating ring. These surfaces are precision lapped to provide a positive seal with minimum friction. At any given pressure, the seal can be designed to maintain proper and constantly effective face loads. It orients immediately to run-out and will resist any torques it is subjected to in operation. The design has high end-play tolerance: Chicago Rawhide engineers have deflected a bellows .100 in. for three million cycles at 1750 cpm and at a temperature of 500° F. with no adverse effects.

A further advantage is relatively light weight and compactness. The C/R metal bellows seal can be designed for minimum axial and radial space. Axially, complete seals can be produced within a ¼ in. cross-section. Radially, dimensions are comparable with conventional end face seals.

The C/R metal bellows seal can also be designed with an extremely low coefficient of expansion. The importance of this factor becomes apparent with the fact that in many applications the operating temperature may change hundreds of degrees in a very few seconds.

Mediums To Be Sealed

Virtually any known liquid or gas may be positively sealed with this design, depending upon duration or service life. From a practical viewpoint, the C/R metal bellows seal is the best design for the sealing of cryogenic and high-energy fuels such as LOX, hydrogen peroxide, fluorine and other missile and rocket propellants.

Where possible, lubrication of the two sealing faces is desirable to prolong service life. However, the medium being sealed commonly acts as the lubricant and may be merely hot gas.

Materials

Sealing faces and mating rings for the C/R metal bellows seal are available in a variety of materials including carbons, carbides, ceramics and various alloyed metals for both high temperature and corrosion resistance. The bellows can be furnished in any of several metals and alloys such as stainless steel, Monel, Inconel X, Ni-Span C and other special alloy steels.

Consult C/R Engineers

Each application for the C/R metal bellows seal is essentially a custom-design and an intimate knowledge of all conditions to be encountered must be known by Chicago Rawhide engineers to produce the correct combination of properties in the seal. Then, whether you require five, fifty or five thousand seals, Chicago Rawhide will design and produce the correct seal to solve your problem.

Helpful Design Data:

We will gladly furnish you with a design guide and space envelope data concerning the C/R Metal Bellows Seal. Just write for Bulletin MBS-1 on your company letterhead.

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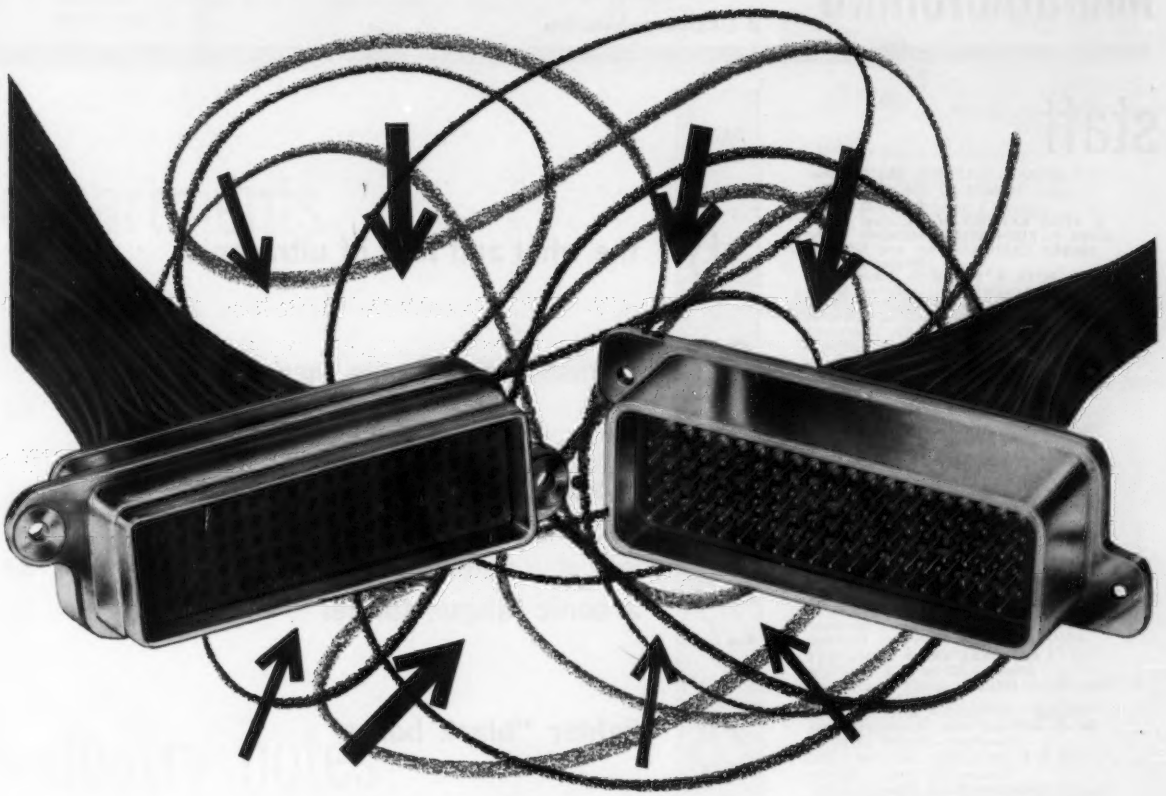

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AIRCRAFT AND MISSILES MANUFACTURING

SEPTEMBER 1959
volume 2, number 9
DESIGN
PRODUCTION
PROCUREMENT
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THE COVER STORY

Sound waves and some of the tools driven by sound waves are the subjects of this month's cover. Piezoelectricity, magnetostriction, and cavitation phenomena have recently been harnessed to contribute their share to the space age. Although interest in ultrasonics is at present closely associated with the production of better weapons, there are growing indications that this young science will contribute to the improvement of Man's lot on this planet.

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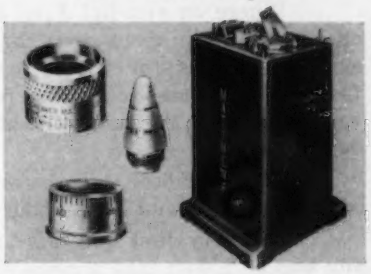

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all about you

Where do you fit? Find out in this kick-off of editorials about you, the aircraft-missile engineers. Facts for the series were gathered from a large cross-section of readers. Perhaps, you were among the many who answered the long questionnaire.

It's never been done before, to our knowledge, so sit back and learn about your colleagues.

The very first question asked in our survey was a "g'wan take a guess" type. "Approximately what would be your best guess as to the number of aircraft-missile engineers in the United States?" Most of the fellows hung their hat on 50,000 (the mode), but some went over the 500,000 mark to bring the mean or average up to 159,000. The mid-point or median was 75,000. Where do you think it is?

Then we wanted to know about some "old stuff" such as military service, education, employment, and age. Of course, there's quite a bit more such as salary, career goal, home ownership, and many, many more items, which will be covered in subsequent editorials.

On the Armed Forces question, we find that slightly over 62 per cent of you have served. According to the age breakdown, more men in the 30 to 34 age bracket (86.5 per cent) and 35 to 39 (81.1 per cent) served than in any other age category. Only 14.7 per cent of those under 25 have been in the service.

Most of those answering were in the Army with the Navy and Air Force ranking second and third. Those under 25 and from 35 to 39 seem to pick the Air Force first. The Navy is first in the 30 to 34 classification. Everyone else ranks the Army first.

An interesting point is that only 6.4 per cent of those who served are now in the reserves.

On education, 89 per cent have been to college; 45 per cent of the college group have taken post-graduate work. The majority hold degrees in mechanical, electrical, and aeronautical engineering.

As far as age is concerned, most of you (26.3 per cent) are 35 to 39 years of age with 30 to 34 close by at 23.2 per cent. The remainder run like this: 40 to 44 (18.2), 25 to 29 (13.1), 45 to 49 (8.5), 50 to 54 (5.5), 55 and over (2.9), and under 25 (2.3 per cent).

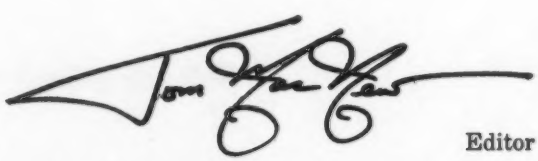
Concerning the rate of employment, figures show that about 3.0 per cent of you joined the industry each year from 1925 and before, through 1958.

Mr. AMM reader has been in the industry for 11 years, with the majority (mode) checking in for eight years. The median tallied at nine years. A few have over 50 years of service to the industry. Gentlemen, our congratulations!

Everyone talks about plant hopping in this business. Let's shut the skeptics up on this one. The average aircraft-missile engineer has only worked at 2.3 companies with most staying, and get this, with just ONE. Actually, 67.2 per cent of you are either still at the same plant where you started or now with your second company.

Next month, we'll run some of the salary data along with career goals, and how much of an increase most of the fellows are requesting to take an out-of-town job.

If you want any special info, let me know.



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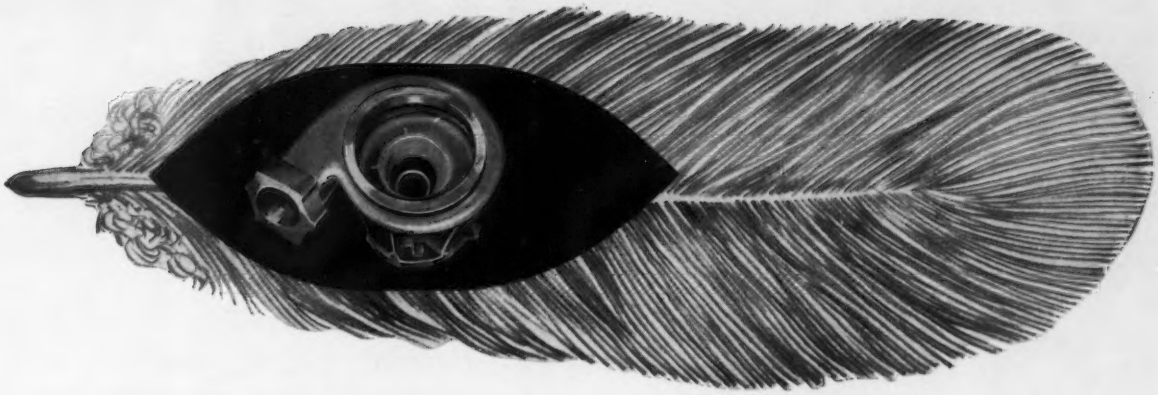
new weight saving material for missiles and high performance jet aircraft



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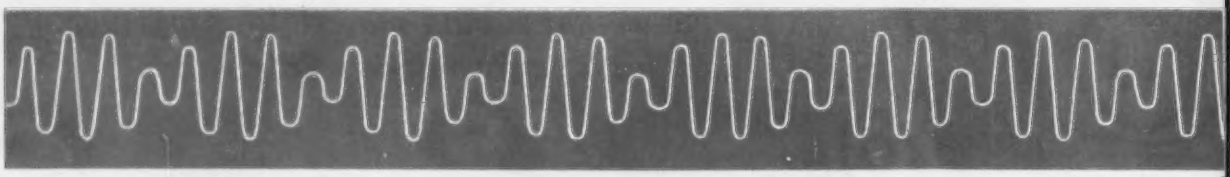
ALLOY (T-6)	U.T.S. (psi)	Y.S. (psi)	E (%)
A-356	40,000	30,000	3
MA-356			
minimum	40,000	30,000	5
maximum	50,000	40,000	2

One of the advantages of MA-356 is that any desired physical within the typical range can be emphasized through careful control of heat treatment of the casting. Even more exciting are the extremely high physicals that have been achieved with MA-356 in favorable casting configurations. Test castings have actually exceeded a tensile strength of 54,000 psi and yield strength of 44,000 psi with 2% elongation.

But no two castings are alike. It's impossible to predict the benefits MA-356 will confer on your sand and permanent mold castings without prints and specs. If you'd like more information on this new alloy, write for Technical Data Bulletin 1001. And when you do, why not ask for your copy of our 58-page light metals casting handbook . . . an engineering guide to aluminum and magnesium sand and permanent mold castings. Rolle Manufacturing Company, 317 Cannon Avenue, Lansdale, Pennsylvania, or call ULysses 5-1174.

ROLLE



the what and how of ultrasonics

cleaning, gaging, flow detection, and machining are major uses; increasing specialized tasks in R & D stage

by S. Peter Kaprielyan

The aircraft and missile industry has found a young but versatile servant in ultrasonics. Total market in ultrasonics is about $25 million; optimism prevails for future.

Cleaning Applications Increasing

Ultrasonic cleaning excels in the removal of mechanically-bonded contaminants from surfaces. Mechanical, electro-mechanical, and electronic components may be cleaned in ultrasonically-agitated solutions; however, parameters vary between applications.

Chief advantages of this process are: vigorous fluid-scrubbing of confined or hard-to-reach areas, reduced handling time, and in some instances, cleaning of assemblies without dismantling. Heat-treat scale, casting sand, and buffing or lapping compound remnants may be removed ultrasonically in minutes. Present dimensional range of process extends from minute parts to the 40-ft fuel gaging system used in Atlas.

A 42-ft tank, developed for this purpose, is in operation in the Culver City plant of Acoustica Associates. Cleanness of gaging unit is vital since it operates in liquid oxygen which reacts violently with certain impurities.

Small Component Assemblies

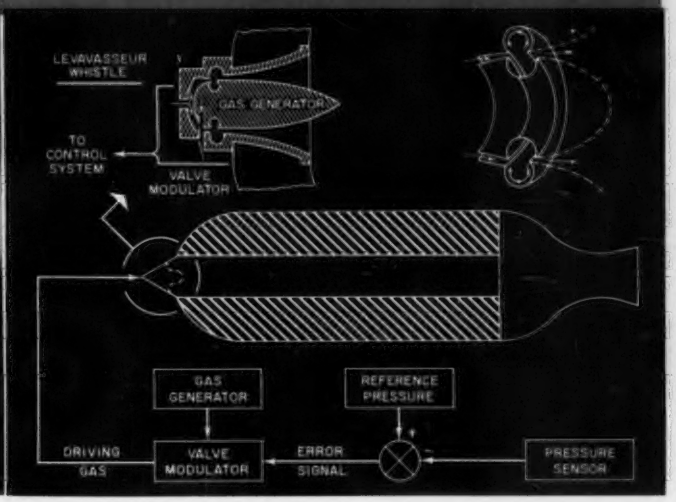
A typical example of small component cleaning is that of the Superite Instrument Corp., in manufacture of tiny differentials. Gears and shafts are cleaned in a chlorinated hydrocarbon solvent before assembly. After assembly and lapping, complete differentials are recleaned ultrasonically, and dried by compressed air. Cleaning and assembly of gyros at Reeves Instrument Corp. takes place in a dust-free "white room." Parts treated with epoxy resins, insulating varnish, and other materials sensitive to organic solvents are placed in capped jars of inert freon before lowering in cleaning tank. The Vernistat Div., Perkin-Elver Corp., has found ultrasonic cleaning especially suitable in manufacture of precision potentiometers. After winding and mounting of resistance toroids of potentiometers, contact surfaces are stripped of insulation. Since this coating is brittle, it tends to flake and lodge between successive turns of wire. If not removed, flakes may cause discontinuities of electrical output.

Cavitation Does the Job

In liquids, sound waves behave as they do in air. That is, they cause areas of rarefaction and compression. These rapid fluctuations of pressure (18,000 to 40,000 cps) create myriads of rapidly forming and collapsing microscopic bubbles. Cavitation is the name of this phenomenon which depends partly on vapor pressure of liquid used. Since vapor pressure depends on temperature, cleaning solution temperatures are raised to help process. When water is used, operating temperature is about 140° F; about 120° F is used for solvents. Implosions of bubbles during cavitation have instantaneous pressures of several hundreds of atmospheres, causing a vigorous "brushing" action; the minute

Scientist at Avco Research and Advanced Development Div. uses ultrasonic pulse system to measure temperature of plasma jet developed by Avco. Quartz probes extending in flame transmit and receive sound pulses which are converted to temperature measurements. Temperatures are above 12,000 F.

Levavasseur whistle will be used for controlling solid-propellant burning rate in Acoustica's R & D project.



size of bubbles allows penetration in hard-to-reach areas. Handling of parts to be cleaned may be accelerated by using wire or screen baskets with openings not smaller than ⅛ in.

How to Excite Liquids

The cavitation producing element of an ultrasonic cleaning system is the transducer. This in turn is driven by an electronic generator using an oscillator as source of power. Depending upon end use, power supply ranges from 110 to 440 v, frequency from about 18 kc to one megacycle, and output from 20 to 10,000 w.

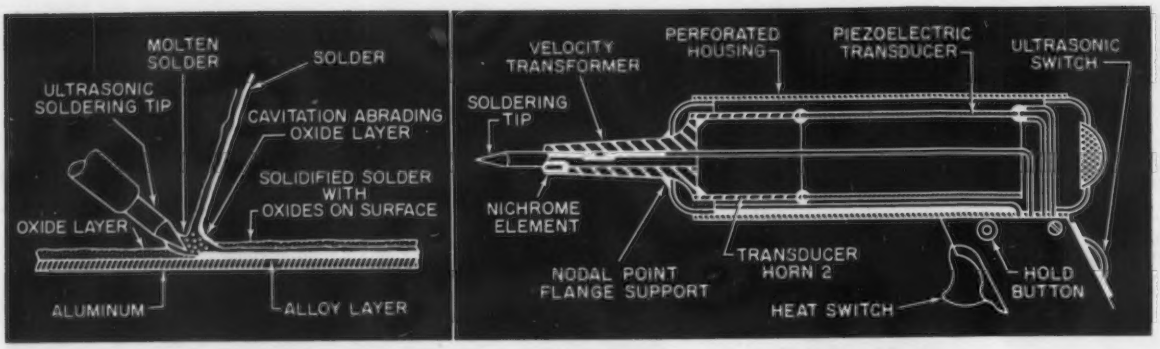
Basically, transducers are of the piezoelectric (or electrostrictive) and magnetrostrictive types. The piezoelectric transducer operates like a quartz slab by contracting and expanding in response to a varying voltage. Among current piezoelectric transducer materials, barium titanate has gained wide acceptance. Such transducers are produced from the polycrystalline form of barium titanate with varying amounts of lead titanate, and calcium titanate; cobalt oxide is also added to improve time and temperature stability. Although ceramic transducers are efficient at relatively low-power levels, they are considered vulnerable to high temperatures, and are not used for building up high acoustic intensity.

Magnetostrictive transducers, usually of nickel or steel alloy, vibrate in response to magnetic field variations, produced by a coil. Conventional magnetostrictive transducer design has incorporated separate stacks of laminations, within wire coils, scattered at intervals across a plate surface. Recently, Dr. R. A. Ramey, Westinghouse Electric Corp., has developed an improved variation of this design by arranging laminations in a continuous, spaced stack. Advantages claimed for this "spaced-laminate" transducer are: even distribution of power throughout vibrating plate, and greatly-improved efficiency even at low levels of acoustic power density. Another innovation in transducer design has been introduced by Acoustica Associates. In this case, instead of a nickel-alloy core surrounded by a coil (magnetostrictive) or ceramic material between two thin electrodes (piezoelectric), solid metal sections are used as major operating elements; the active transducer material is located near the center of the assembly. Purpose of this design is to achieve greater motion amplitude and improved heat dissipation.

Sound waves generated by transducers used in cleaning equipment do not radiate but flow perpendicular to transducer face. Hence, units mounted on tank bottoms create cavitation straight upward, and those on tank sides produce cavitation in a horizontal path. Optimum cleaning is achieved in direct path of cavitation. Lower frequencies convert more of power input into cavitation for general cleaning; higher frequencies produce narrower beams and are more effective for confined areas.

Thickness Gaging and Flaw Detection

High-frequency ultrasonic waves (500 to 10,000 kc) behave somewhat like light waves. They travel mostly in straight lines because of



Ultrasonic soldering process is shown (left) with a cross section of a Vibro-Ceramic's soldering gun (right). Mechanical energy is coupled from transducer to tip by a velocity transformer, electrically analogous to a voltage step-up.

ultrasonics . . . continued

shortness of wave length, and are reflected by discontinuities of medium in which they move. Back surfaces of metals also constitute reflective surfaces for sound waves. These characteristics have been used in "pulse-echo" devices effectively to measure thickness of materials, and to locate sub-surface defects from one side.

Wyman-Gordon Co. utilizes ultrasonic inspection, for flaw detection, during several stages while forming the massive copper nose cones for the Atlas (AMM August). The 80-in. beryllium heat sink for Project Mercury capsule will likewise undergo final ultrasonic inspection before delivery to McDonnell Aircraft Corp.

Ultrasonics is also being used to test fuel elements both before and after irradiation at the Hanford Atomic plant of the AEC. Aluminum cladding on fuel elements is used both as conductor of heat and as a corrosion barrier between uranium metal and cooling water. Imperfect bonding between aluminum jacket and fuel element may result in failure. Testing of radiated elements is conducted under a 10-ft water shield; fuel rods are scanned both radially and longitudinally as they rotate on submerged rollers.

Ultrasonic testing of welds has been used to locate cracks, porosity, lack of fusion, slag inclusions, etc., but acceptance standards have varied between companies and applications. To further extend this application, ASTM and ASME are engaged in preparing specifications and standards.

Thickness of integrally-stiffened skins, chemically-milled panels, and sheetstock is also being measured by pulse-echo testers. Presently Nike-Hercules, Minuteman, and Titan nose cones, in production at Lycoming Div., Avco Manufacturing Corp., are likewise checked for proper thickness ultrasonically. Wall thickness measurement accuracy for Nike-Hercules cones is ± 0.006 in.

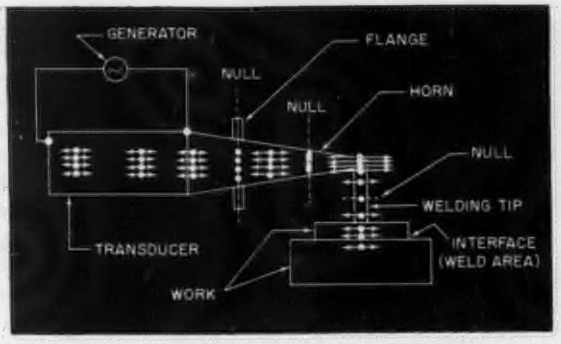
Machining

Ultrasonic machining is associated with precise metal-removal tasks difficult to accomplish by other methods. Specialized drilling, cutting, slicing, trepanning of intricate shapes, engraving and routing is done ultrasonically; metals, ceramics, carbides, jewels, silicons, ferrites, germanium and other hard or brittle materials are thus rendered workable. Ultrasonic machining is also used in die sinking. Production of accurate, narrow slots with square corners, as in hydraulic servovalves, often creates machining difficulties. In a typical case, a Raytheon Impact Grinder was used to cut a 0.004-in. wide and 0.050-in. deep slot, in stainless steel, in 10 min. The cutting tool was simply fashioned from a piece of commercial shim stock 0.004-in. thick $\frac{5}{8}$-in. wide, and $\frac{1}{2}$-in. long.

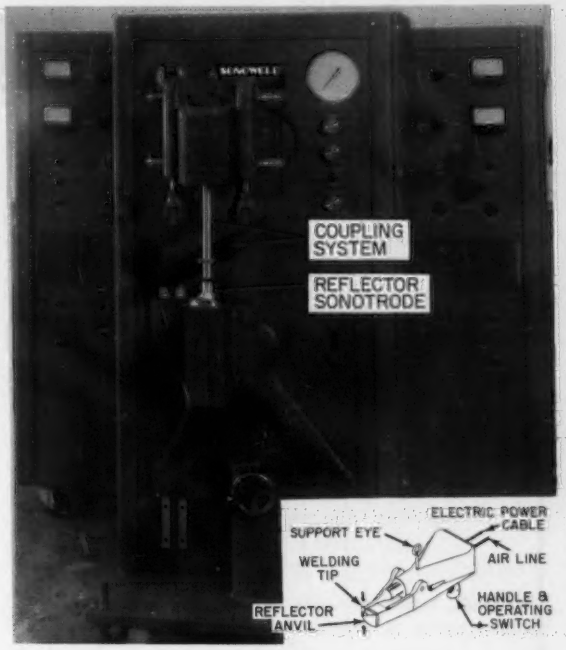
Transducers with a cooling medium are used in machining equipment. Operating frequencies range from 20 to 25 kc; power output varies from about 100 to 1000 w. Although the resulting tip motion is measurable in thousands of an inch, abrasive particle impact is estimated as 150,000 times particle weight.

Cavitation of abrasive slurry between cutting tip and workpiece plays major role in process. It keeps abrasive particles in suspension, promotes uniform dispersion of particles, removes resultant chips, and acts as coupling medium between the tip and the work. Motion of cutting tool is parallel to tool axis. As a result, abrasive particles driven by cutting tool generate the exact counterpart of the tool face in workpiece.

A recent innovation by The Sheffield



Simplified diagram of Gulton ultrasonic welder shows how vibrations from transducer are transmitted by horn to welding tip, in shear wave parallel to surface to be welded.



Sonoweld 4000-w ultrasonic welder, and 2000-w portable spot-type welding head (inset) are illustrated.

Corp. combines an ultrasonic machining unit and an electric-discharge machine on a single base. This is for preliminary roughing of cavities by electric discharge, then finishing by ultrasonic machining. Use of ultrasonic energy in conventional machining techniques is also being investigated. That is, effects are being studied of vibrating cutting tools to increase cutting speeds.

Welding, Soldering and Brazing

Birth of ultrasonic welding is attributed to a "serendipity" accident. While studying effects of ultrasonic energy on resistance welding, the ultrasonically-excited electrode produced a welded spot. This was considered remarkable because it occurred without the benefit of welding current. Ultrasonic welding today still holds many unknowns, but recent progress in the art has achieved encouraging results.

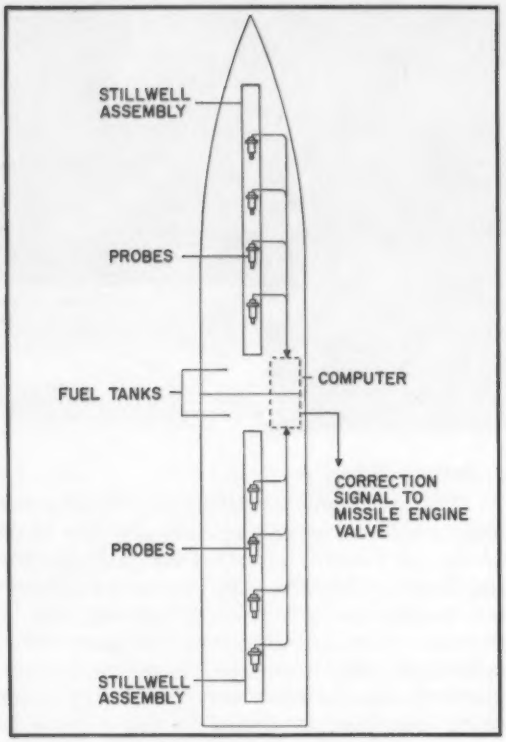
Ultrasonic welding equipment includes: (1) a transducer-coupling system for generating vibratory energy and delivering it to the weld area; (2) a support for the workpiece, (3) a means for applying clamping force to the weldment, and (4) an electronic generator to supply high-frequency electric power to the transducer. Equipment operating range is between 3000 and 85,000 cps; current power-requirements vary from 100 to 4000 w. Special equipment for spot-type welding with capacities up to 8000 w has been developed. Clamping pressures for holding workpieces together, by welding tip, vary from a few pounds to about 300 lb. For spot-welding, cycle duration ranges from a fraction of a second to five seconds.

How Welding Works

The mechanics of ultrasonic welding are likened to seizing or galling between two metal surfaces. A recent report from Battelle Memorial Institute describes the process as follows: "Basic mechanism of ultrasonic welding can be understood by considering what happens when two pieces of metal are placed in sliding contact. Removal of material from surfaces sliding under pressure has been attributed to the welding of peaks on metal surfaces. The reasoning goes like this: high yielding pressures exist where peaks make contact and heat is generated by the sliding friction. As a result of the intimacy between two surfaces, a bond is formed and welding takes place. The bonding mechanism is thought to be recrystallization and/or a fusion process at the interface."

With current technique a relatively limited spectrum of butt, spot and seam welds may be effected ultrasonically. Moderately ductile materials such as aluminum (clad and unclad), copper, mild steel and gold are welded with relative ease. The process excels in joining fine-wire and foil materials. Foil can also be welded to heavy gage material. An inherent advantage of ultrasonic welding is the absence of heat as associated with conventional pressure or resistance welding; surface deformation is likewise minimal.

The progress of ultrasonic welding can perhaps be summarized by quoting from a recent report published by Aeroprojects, Inc. "In 1955, 2024-T3 Alclad aluminum sheet could not be ultrasonically welded. In 1956, 0.040-in. sheet



Schematic drawing of Acoustica's propellant monitoring system is shown above; details of ultrasonic sensing probes are given below.

FUEL SENSING PROBE CHARACTERISTICS

Sensing accuracy: 0.1 in., not affected by vapor foams or clinging droplets

Power requirements: 28 v d.c. at 15 ma (max) or 115 v a.c.

Control circuit: single-pole, double-throw relay

Resonant frequency: 78 to 85 kc

Response time: 25 milliseconds (max)

Shock: control unit, over 15 g's; probe, 100 g's

Relay contact rating: 2 amp at 28 v d.c.

Pressure: probes capable to withstand up to 4000 psi

Repeatability: 0.003 in.

Environmental conditions: meet shock and vibration per MIL-E-5272A and MIL-S-21277 (AER)

Corrosion resistance: sensing probe housing corrosion-resistant in most compounds

Spark hazard: none

Mounting position: both probe and control unit operate in any position

Performance at altitude: not affected by altitude

Temperature range: special probes, —320 to +350° F; control units, —65 to +185° F

Dimensions: typical probe diam. 0.75 in.; length, 2.20 in.

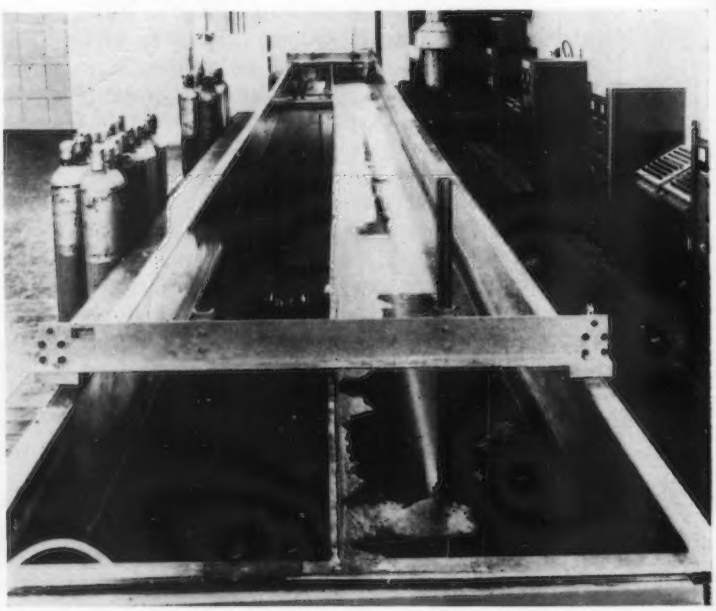
was welded but barely met the minimum strength requirement for resistance spotwelds indicated in Military Specification MIL-W-6860. By 1957, 0.063-in. sheet was welded with strength considerably in excess of the MIL-W-6860 requirement. Early in 1958, this sheet material was welded in thicknesses of 0.090-in. and the spot strength substantially exceeded the military specification requirement. For various reasons, we are convinced that more powerful equipment will satisfactorily join thicker and harder materials."

Ultrasonic soldering and brazing offer the advantage of fluxless joining. Again cavitation plays an important part in these operations; it breaks down surface tension of solder and braze metals, disperses surface oxides or contaminating films on metallic surfaces, and insures wetting of surfaces evenly. A wide range of similar or dissimilar metals may be soldered ultrasonically, but the process has been mostly associated with the joining of aluminum. Brazing has been used for joining heavy-gage insulated aluminum; coated copper wire has also been joined by brazing without necessitating stripping. Silicone and germanium transistor elements have been joined with ultrasonic equipment on a production basis.

Liquid-Level Monitoring

Liquid level control problems in aircraft and missiles (and other industrial fields) are also being solved ultrasonically. Such systems have been monitoring liquid propellant, fueling and dumping operations, staging cutoff, and over-

Atlas fuel monitoring system is washed and rinsed in Acoustica's 42-ft, 2400-gal, stainless-steel tank. A 2-in. water-heated interchamber surrounds twin-section tank.



flow control. Among missiles, Atlas, Jupiter, Redstone, and Vanguard utilize these systems. A number of high performance aircraft on the board will also use fuel, oil, and hydraulic systems monitored by ultrasonic devices.

A typical missile propellant utilization system includes a series of ultrasonic probes in each tank. As liquid level drops, it uncovers a probe. A relay in an associated control unit is energized, applying a signal to a computer unit connected to engine valve. If propellant utilization from one tank is too fast, a control signal from computer decreases flow at engine. Engine operates on fuel ratio based on specific gravity (density), while probes sense decrease of volume. Therefore, computer converts volume data to density data in programming valve correction signals. To minimize sloshing or standing waves, ultrasonic probes are located in tubular stillwell assemblies.

For automatic missile tanking and voiding operations, three level-sensing probes are placed vertically near top of tank, and connected to circuit controlling pumping operation. As liquid level reaches lowest probe, pumping is slowed. When liquid level reaches middle probe, pump is shut off. The third shut-off probe, immediately above middle one acts as a fail-safe device. Remote control of ground support systems may likewise be effected, by sequencing of piping systems; ultrasonic probes may also be used in calibrating volume flow meters and detecting air in fuel lines.

Liquid level can now be monitored on a continuous basis. This is done by measuring the time required for an ultrasonic compression wave to travel from the tip of a sensing probe to the liquid surface and back.

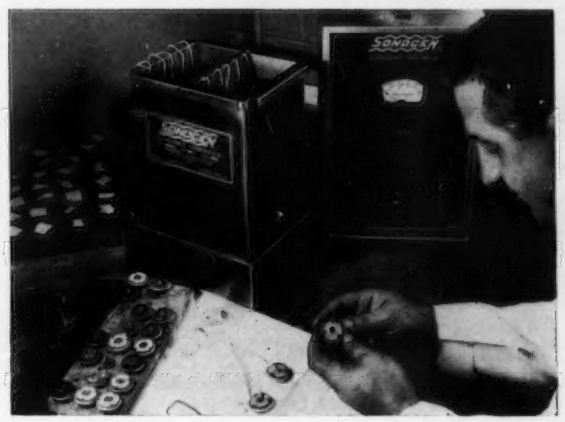
Taming Solid Propellants

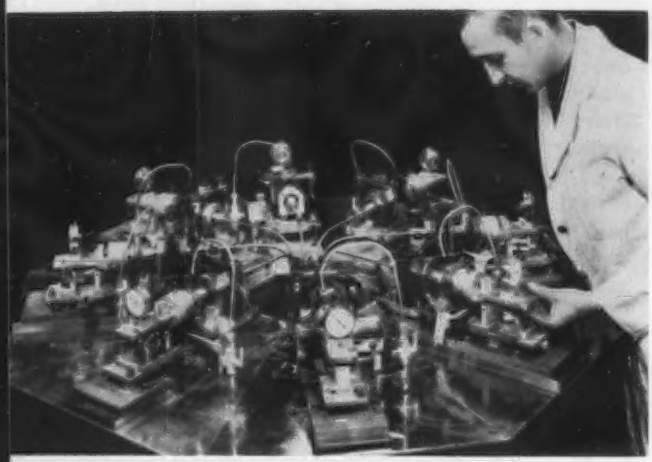
Probably the most talked-of use of sound waves, is for the control of solid-propellant burning rates. Award of a NASA R & D contract, for this purpose, was announced recently. If feasibility is determined conclusively, a new milestone will be established in solid-propellant rocketry. Thus far, the simplicity feature of solid fuels has been offset by the difficult throttling problem. Concept of sonic burning-rate control represents a marriage of two sciences—acoustics and thermodynamics, and may usher-in a new field, perhaps "acousti-combustion." Key figures in this project are Dr. Summerfield of Princeton University and Dr. Junger of Cambridge Acoustical Associates.

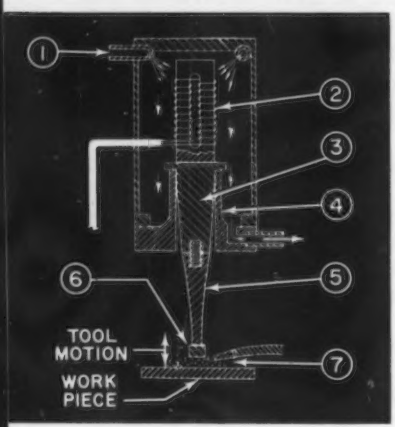
It is known that sound waves influence the rate of heat-conductivity in solids. It is believed, therefore, that by using a great range of sound control, rate of heat-propagation and burning may be increased. In solid grain, if the burning cavity is of circular cross-section, enlargement through burning exposes more grain, and increases pressure on rocket casing progressively till complete burnout. Additional casing wall thickness, hence extra weight is usually added. Varieties of burning cavity shapes have been designed to prevent the above acceleration by initially presenting greater grain surface to combustion; combustion then progressively decreases burning-cavity cross-section by reducing

Narda's 6-gal, two-stage cleaner vapor degreases and decarbonizes aircraft engine parts.

Vernistat precision a.c. potentiometers are cleaned ultrasonically after stripping of insulation from contact surfaces.

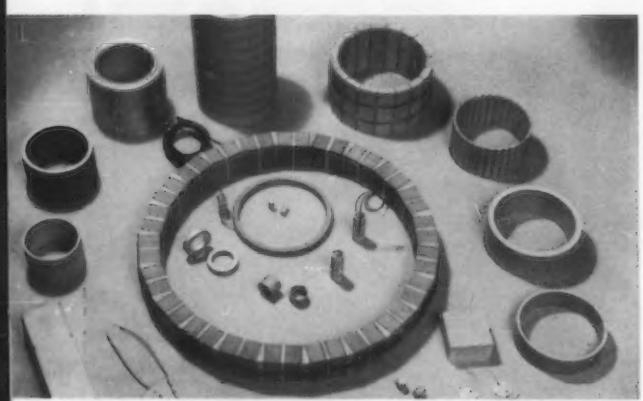






Up to eight ultrasonic machining operations can be performed simultaneously on this Sheffield-Cavitron tool. Single magnetostrictive transducer in table-well transmits 20,000 cps to each station through curved lines. A remote 1000-w generator is used.

Raytheon Impact Grinder incorporates the following elements: (1) cooling medium, (2) transducer, (3) tapered cone, (4) resonant support, (5) tool holder, (6) tool, and (7) abrasive-slurry dispenser.



Piezoelectric ceramic transducer elements shown are made by The Arnold Engineering Co.

a star or cruciform section into a circle.

Excitation of combustion gases is not directly meant to reduce combustion rate but to increase it. However, if a controllable type of combustion acceleration proves feasible, then solid propellant rockets may be produced which may normally "idle" till "revved-up" by sound waves. The proposed system requires the following basic elements: (1) a pressure sensor, (2) a pressure reference, (3) a valve modulator, and (4) a sonic-energy source. In operation, combustion chamber pressure will be determined by the pressure sensor and compared to pressure reference; pressure reference will be proportional to desired thrust. An error signal generated on the basis of pressure difference would be proportional to desired SPL (sound-pressure level) in combustion chamber. By regulating the amount of a gas, flowing through a valve modulator, the output of a sonic-energy source will be regulated; the gas may be a combustion by-product, or be generated separately. The amount of sonic energy injected into combustion chamber, in turn, determines SPL and, through its effect on combustion, chamber pressure.

In the proposal, sonic energy source is the Levavasseur whistle, a compact, gas-driven siren without moving parts. The siren could be located at forward end of combustion chamber, and would communicate directly with it.

Other Areas of Promise

- Addition of ultrasonic energy to soldering and brazing has extended the usefulness of these joining techniques; there is likewise reason to believe that conventional welding techniques may be improved greatly through added excitation. Anticipated benefits may include grain refinement in solidifying melts, degassing of melts, contamination control, etc.
- Ultrasonic de-icing of vulnerable areas in aircraft fuel systems, such as filters and valves, may also merit investigation.
- Electroplating, anodizing, and oil quenching are additional processes which have improved by application of vibratory energy.
- Preliminary investigations by Dr. Sittel of Franklin Institute Laboratories, have indicated that early detection of fatigue in metals by ultrasonics may also become a reality.

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Engineering problem:

Pressure-tight fastening of transit cases

The solution:

A specially modified LINK-LOCK

Applied Design Company engineers worked with Simmons to develop this successful LINK-LOCK application

Simmons LINK-LOCK, with design modifications developed in cooperation with the Engineering Department of Applied Design Company, Buffalo, New York, resolves special closure requirements in rigidly specified transit cases like the aluminum equipment container shown.

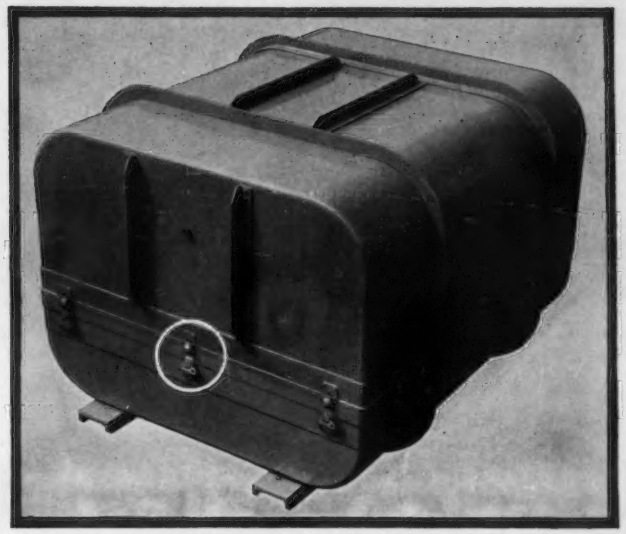
Here, the bowed LINK-LOCK engagement blade provides the double advantage of maintaining constant fastener pressure and permitting considerable mounting tolerance. This container is just one of many important products in which Applied Design specifies standard and special Simmons Fasteners.

Here's why LINK-LOCK is ideal for use on military cases produced to exacting specifications as well as on inexpensive commercial containers:

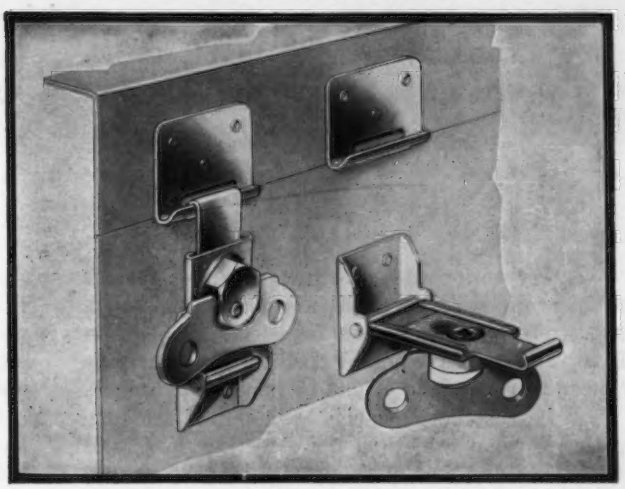
- Impact and shock resistant (positive-locking).
- High closing pressure with light operating torque...insures pressure-tight seals where required.
- Available in 3 sizes, for heavy, medium, and light duty.
- Compact design...lies flat against case even when unlocked.
- Opening and closing by wing-nut, screwhead, or hex nut.
- Flexible engagement latch design...can be varied to suit different conditions.

Also available: Spring-Loaded LINK-LOCK. Ideal for the less expensive containers where costs won't permit precision production. Spring provides take-up to compensate for set in gasketing, irregularities of sealing surfaces, and mounting inaccuracies.

SEND TODAY for the Simmons Catalog for complete information and engineering data on LINK-LOCK and other Simmons Industrial Fasteners. Engineering service is available; outline your particular fastening problems. Samples on request.



Twelve special loop-blade LINK-LOCK fasteners are used in this aluminum transit case designed by Applied Design Company.



Standard No. 2 LINK-LOCK (Medium-Duty). Available with screwhead, wing-nut as shown, or hex nut.

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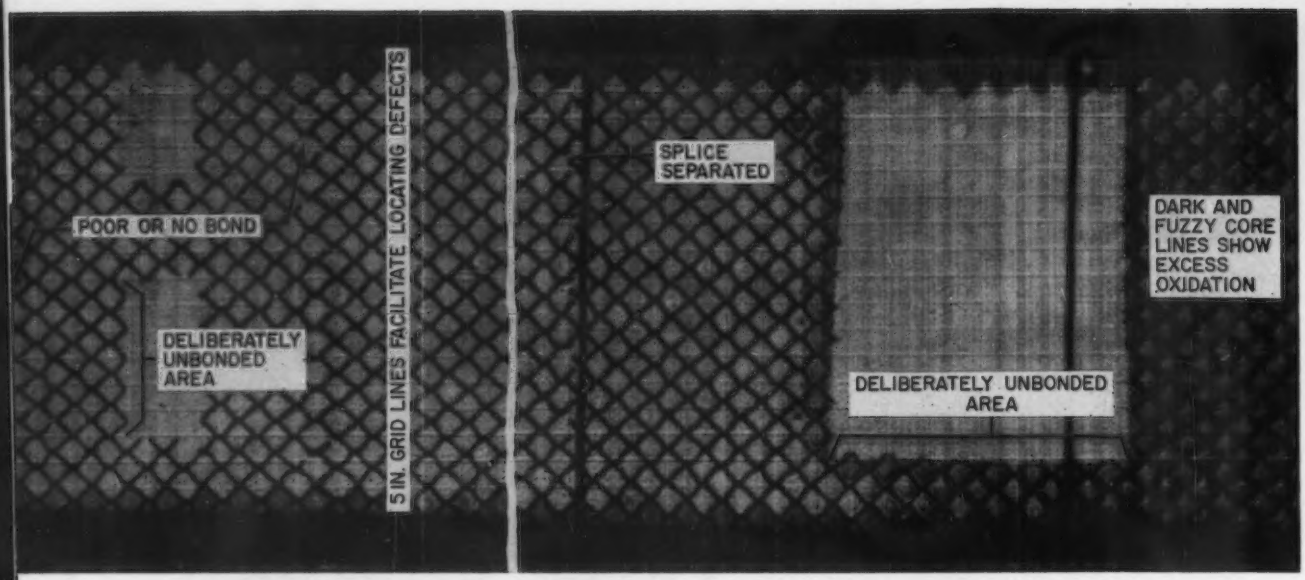

POOR OR NO BOND
DELIBERATELY UNBONDED AREA
5 IN. GRID LINES FACILITATE LOCATING DEFECTS
SPLICE SEPARATED
DARK AND FUZZY CORE LINES SHOW EXCESS OXIDATION
DELIBERATELY UNBONDED AREA

Reproduction of actual recording strip with known defects shows how honeycomb panels are evaluated. In practice, 1-to-1 size is used. Heavy vertical lines (5 in. apart) facilitate location of defects.

ultrasonics in braze inspection

pulse-echo techniques, using a focused beam show braze integrity of thin stainless-sandwich; equipment gives immediate, permanent record of tests

by Philip Geddes

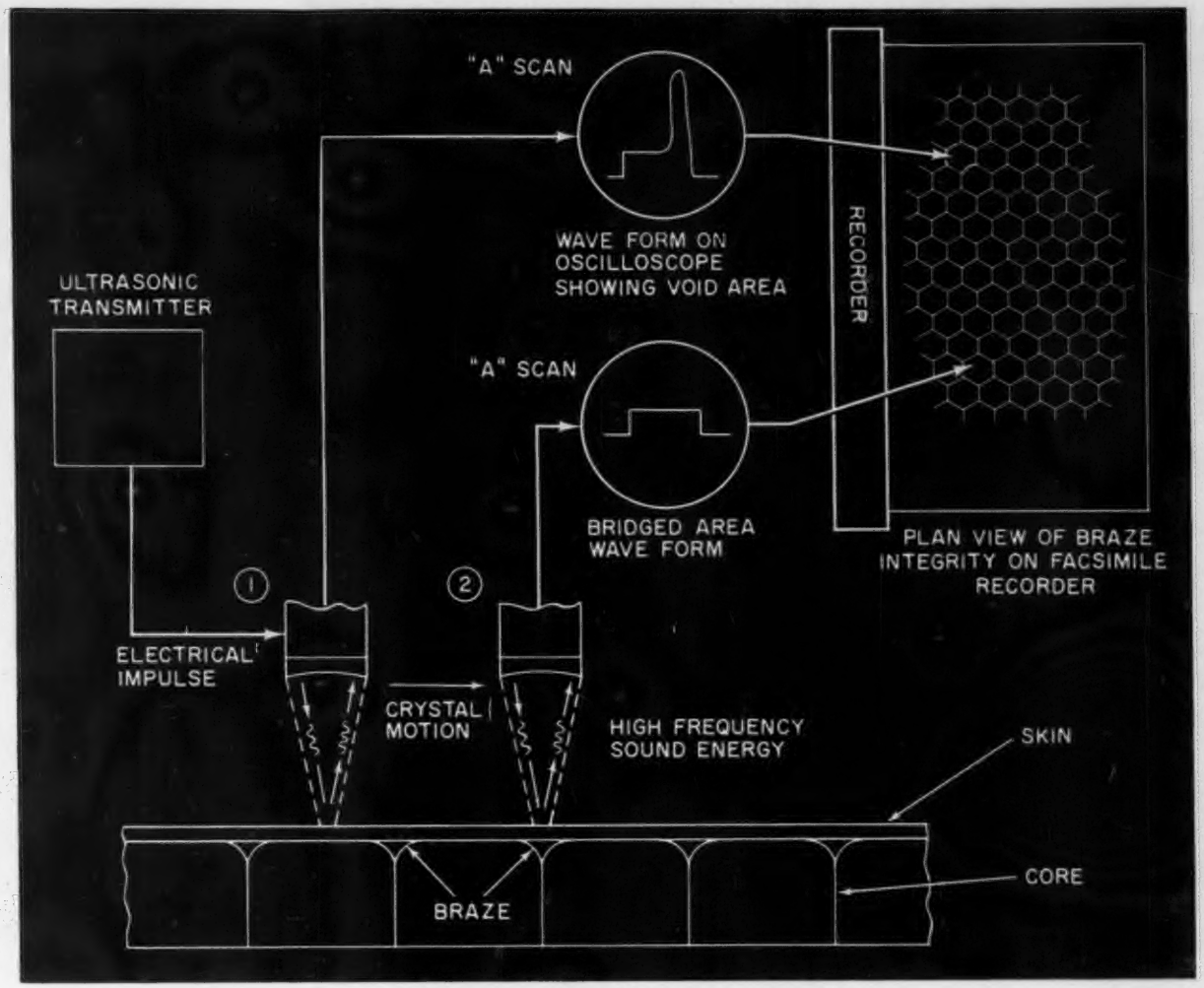
Inspection of braze integrity is a serious problem in stainless-steel honeycomb sandwich. North American Aviation faces this problem on B-70, and F-108 where PH 15-7 Mo skins are brazed to core made of 0.0015 in. foil (average).

Ultrasonic pulse-echo techniques are providing a reliable method for detecting voids and distorted cells. But, it should be emphasized that ultrasonic testing is only one of three methods used to inspect completed panels. Radiography (X-rays) and fluoroscopy are still required for checking metal-to-metal bonds on closeouts, doublers, and external attachments. They are also used to detect crushed core. There is some promise that advanced ultrasonic techniques can also be applied to these areas. At present, according to North American, node flow down the cell walls can be accurately detected only with X-ray and fluoroscopy.

Why all this inspection on honeycomb? Because, manufacturing brazed honeycomb sandwich is exceptionally difficult. The variables that must be controlled in production are many. The only way to insure structural integrity of each square foot of sandwich is to inspect it inside. In the B-70 and F-108, where small brazed-honeycomb panels are welded into large areas of primary wing and fuselage structure, imperfections must be detected before the joining. It is extremely costly to scrap large joined panels since the cost per square foot of this sandwich is higher than any other form of construction ever employed in the aircraft industry.

Lots of Time, Lots of Money

North American, along with ultrasonic equipment manufacturers, are putting a lot of time, money and energy into refining pulse echo



SCHEMATIC—WAVE GENERATION TO READOUT

inspection. The equipment installed at N.A.A.'s Los Angeles division represents a major development effort. It is a development from similar gear used for checking adhesively bonded aluminum honeycomb sandwich. Major differences between the original equipment and the refined version lie in the use of higher checking frequencies, crystal transducer design, beamed ultrasonic output, and direct writing facsimile output recording. The existing tank is capable of handling 6 x 12 ft panels. A second tank will be required for 10 x 20 ft panels.

Two Basic Techniques

Two basic testing techniques will be used:

- Complete immersion, for flat panels.
- Contour following, for curved panels.

In the first method, the flat panel is completely immersed in water, and a sonic transducer close to the surface of the facing sheet moves backward and forward across the panel in a scanning motion.

With contour following, water is emptied from the test tank. The sonic transducer, mounted on gimbals, describes an identical scanning motion to the immersion technique, but follows the curve of the panel. The sound waves travel to and from the panel through a stream of water jetted from the gimbal head. Very little water is required for effective coupling.

The angle of the sound waves transmitted to the panel and reflected back to the receiving head is important in immersion, and in contour following in order to maintain full signal strength. If the beam is more than one deg off the vertical from the face of the panel, too much

Recording paper flowing from readout unit enables operator to see and interpret test results immediately. Prime and vendor teamwork were essential in putting together ultrasonic tester.

braze inspection . . . continued

echoed energy is lost with consequent reduction in sensitivity. Difficulties in keeping the beam normal to the panel face, in early tests, required redesign of mechanical tracing section of the machine to eliminate lost motion. Synchronization of location of the sound beam to the location of the pen on the facsimile recorder had to be within plus or minus 0.010 in., otherwise the output plot would not correspond to the point being read on the panel under test.

Focused-Beam in Pulse-Echo Testing

The crystal in the sound head of an ultrasonic tester is a transducer which converts electrical energy into sound energy at a fixed frequency. A different crystal is required for each testing frequency.

In the early work done on adhesive bonded aluminum honeycomb sandwich, good results were achieved with lithium sulphate crystals selected in the range between 5 to 15 megacycles output. In the brazed honeycomb application the most commonly used stainless steel expanded core has a wall thickness of 0.0015 in. Here, due to the thinness of the core walls, the earlier techniques were ineffective in giving sensitive accurate readout.

Research centered around using crystals of lithium sulphate, ceramics, and quartz, operating at frequencies from 2½ to 25 megacycles. Concentrating the beam of sound to raise the signal strength also received attention. The result of the work is the high-frequency focused beam. A simple truncated cone mounted on the sound head concentrates sound in a narrow beam of about 1/16 in. diameter. Distance from the crystal to face of panel is approximately two inches. Test results show that lithium sulphate crystals, with focused beam output, provide ample sensitivity and signal strength.

Interpretation of Results

Formerly, ultrasonic wave forms were interpreted by an operator reading wave shapes from an oscilloscope. Although the basic wave forms are simple, and individual voids easily detected, this method left much to be desired. Equipment now produces a continuous record on a wide paper strip. The image on the strip gives an easily-read permanent record of every inch of panel inspected, on which every cell shape can be seen as if photographed. The reproduction is one to one. This means that the recording paper can be laid on the panel being inspected and any defects marked directly onto the panel below.

Inspection Sequence

(1) The panel to be tested is marked out in a series of 5-in. squares. Pressure sensitive commercial chart tape is used for marking. The squares are used to key the panel to the facsimile recording. Panels without edge members are sealed along the edges with pressure sensitive lead tape. Water pressure would otherwise force water into leaks.

(2) Panel level is checked to horizontal and squared off as need be.

(3) Crystal of correct frequency for particular test is selected and installed in sound head. Generally, on facing sheets less than 0.020 in. thick a 15 megacycle crystal is used. On facing sheets more than 0.020 in. thick a 10 megacycle crystal is used.

The indexing mechanism which determines the number of scans per inch is set. The number of scans is never less than 4 cells and can go as high as 64 in. Index setting is largely dependent on cell size. Obviously, more lines per inch are required on small cells than on large to measure the degree of brazed contact between core edge and face. Once set in motion the sound head travels across the panel under test in automatic sequence. Real time test results flow from the recorder.

✦

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machining glass-base laminates

how to cope with the problems of shaping these tough, new materials

by **E. G. Graesser**, chief engineer, quality control and standards, National Vulcanized Fibre Co.

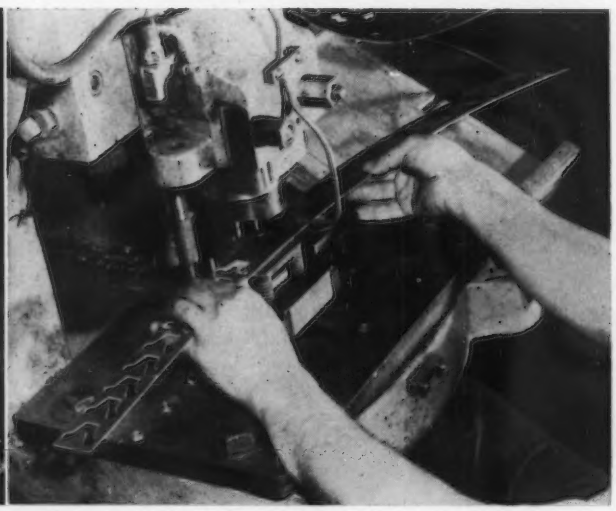
In an age when dramatic technological breakthroughs are occurring with increasing frequency, the high performance characteristics of glass base laminated plastics are assuming new importance to the design engineer. These laminates offer advantages of good flame and heat resistance, high mechanical strength, and good moisture resistance.

Unfortunately, certain problems in manufacturing arise from these desirable physical properties. Because of the toughness of glass base laminates the practicability of volume production in laminated materials has met with some doubt.

However, over the years, specific techniques have been developed for successful machining, and many of the problems have been resolved. The following basic recommendations for machining should be of interest not only to those who are encountering these materials for the first time but perhaps even to those who have

In sawing full-sheet glass base laminate with circular saw, material is fed as fast as saw will cut without forcing. Idling dulls saw.

Sheets up to 3/32 in. can be punched with good results. Carboloy or die steels are used in punches.



already had some experience in machining glass base laminates.

It is important to bear in mind that when machining these materials parallel to the laminations, there is always the danger of splitting. This problem can be handled if the piece is firmly clamped during machining operations and if care is exercised during cutting operations. In many cases, the same machining operations employed in the fabrication of metals and wood may be adapted to glass base laminates. Slight changes in tools and machining speeds are necessary. With glass base grades of Phenolite laminated plastic, the following techniques have been very successful.

Sawing

A diamond impregnated wheel with copper body 1/16 in. thick and a 12 in. diam, run at 3000 to 3600 rpm gives good results cutting dry. A good exhaust system is necessary to remove dust. The material is fed by hand into the saw as fast as it will cut without forcing the saw. Idling creates friction and heat, which cause excessive dulling and burning. A flood of water on the work and wheel can be used when necessary to prevent overheating.

Band sawing is one of the most difficult and expensive operations. For good results, steel blades with hardened teeth and a soft back can be used. Work should be fed lightly and the blade should be kept sharp. Diamond coated band saw blades are now available and are superior to steel. Sawing can be done dry with a good exhaust system.

Turning glase base tubing is performed on standard lathes. Hard faced cutters with zero rake are used.

Shearing and Slitting

Thicknesses up to 3/32 in. can be sheared and slit. The same standard practices are used for shearing and slitting laminated plastic sheets.

Punching or Drilling

Punching practices for glass base materials are the standard ones used for laminated plastics generally, although die life is shorter. The use of carboloy and special die steels helps to increase die life. Sheets up to 3/32 in. thickness can be punched with good results.

When drilling glass-base grades, a carbide drill should be used. The materials can be drilled with a good exhaust system. A flood of water on the work and drill can be used when necessary to prevent overheating and dulling of drills. High speed drills, nitrate treated, can be used, but must be sharpened more often. Care should be taken when sharpening so that the drill is cut back far enough to the original body diameter of drill. Spindle speed for these grades is 4800 rpm for 1/4-in. diam drills

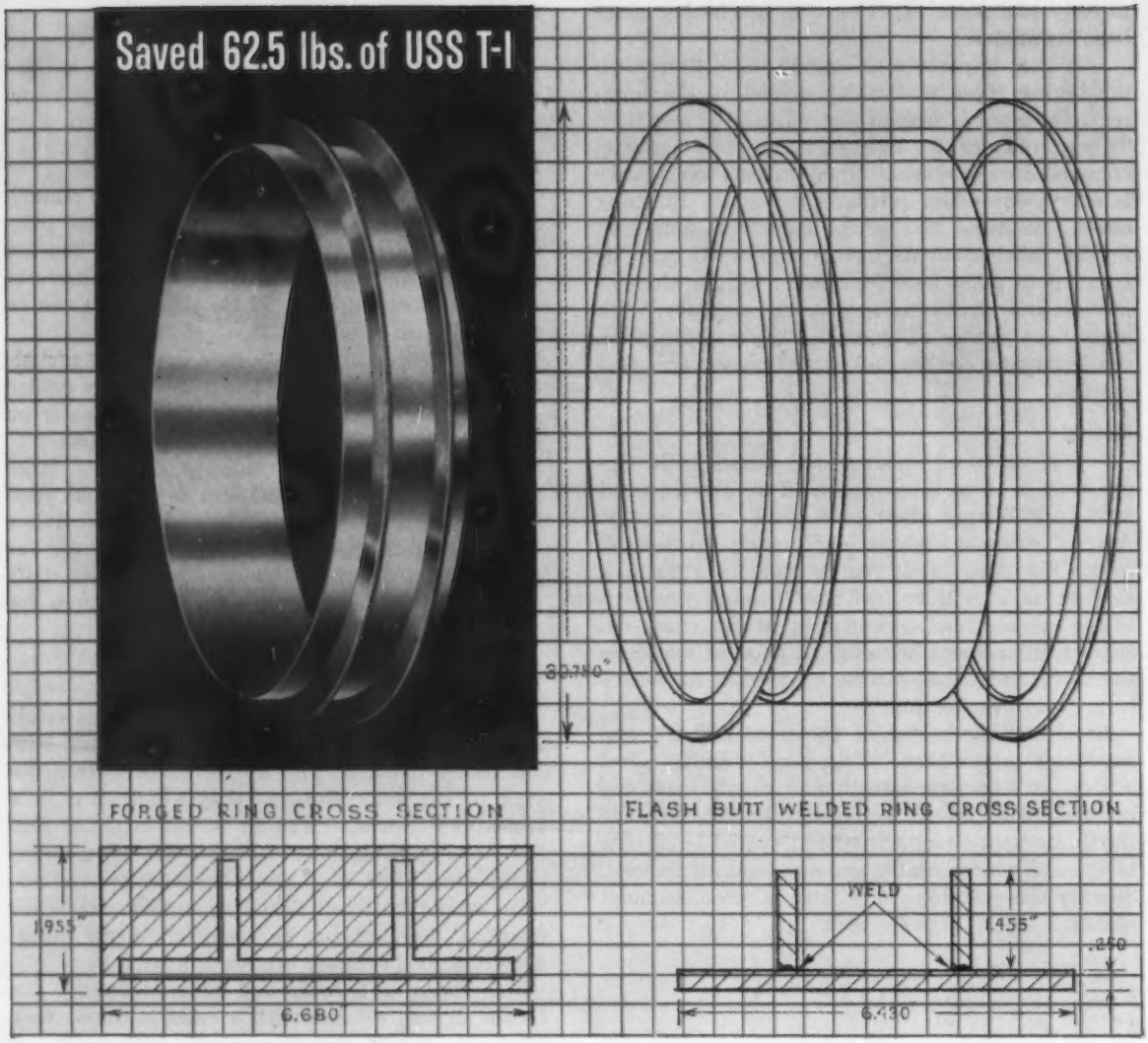
Tapping and Threading

The methods for tapping these materials are much the same as for tapping paper base laminated plastics. The abrasiveness may cause taps to cut very close to size, resulting in a tendency toward binding when backing out. Standard high speed steel taps can be used on short runs. For any sizeable quantity, carbide taps should be used. Taps should be purchased oversize. Coolant can be used, but is not necessary if a good exhaust system is available.

External threads and internal threads can be cut dry on a lathe with a carbide-tipped tool. Fine cuts should be taken to give best results. A coolant can be used, but is not necessary.

Machining

Conventional machining, such as turning, boring, facing and milling can be done on automatic screw machines, standard and production lathes, hand turret lathes and standard milling machines. Carbide-tipped tools and cutters should be used with surface speeds below those used for paper base laminated plastics. Tools should be ground with a zero rake, and machining can be done dry if an exhaust system is incorporated. Techniques are being refined almost daily so that glass base machined parts, though very difficult in the recent past, can be turned out with speed and perfection, if operators are kept up to date with new and changing techniques.



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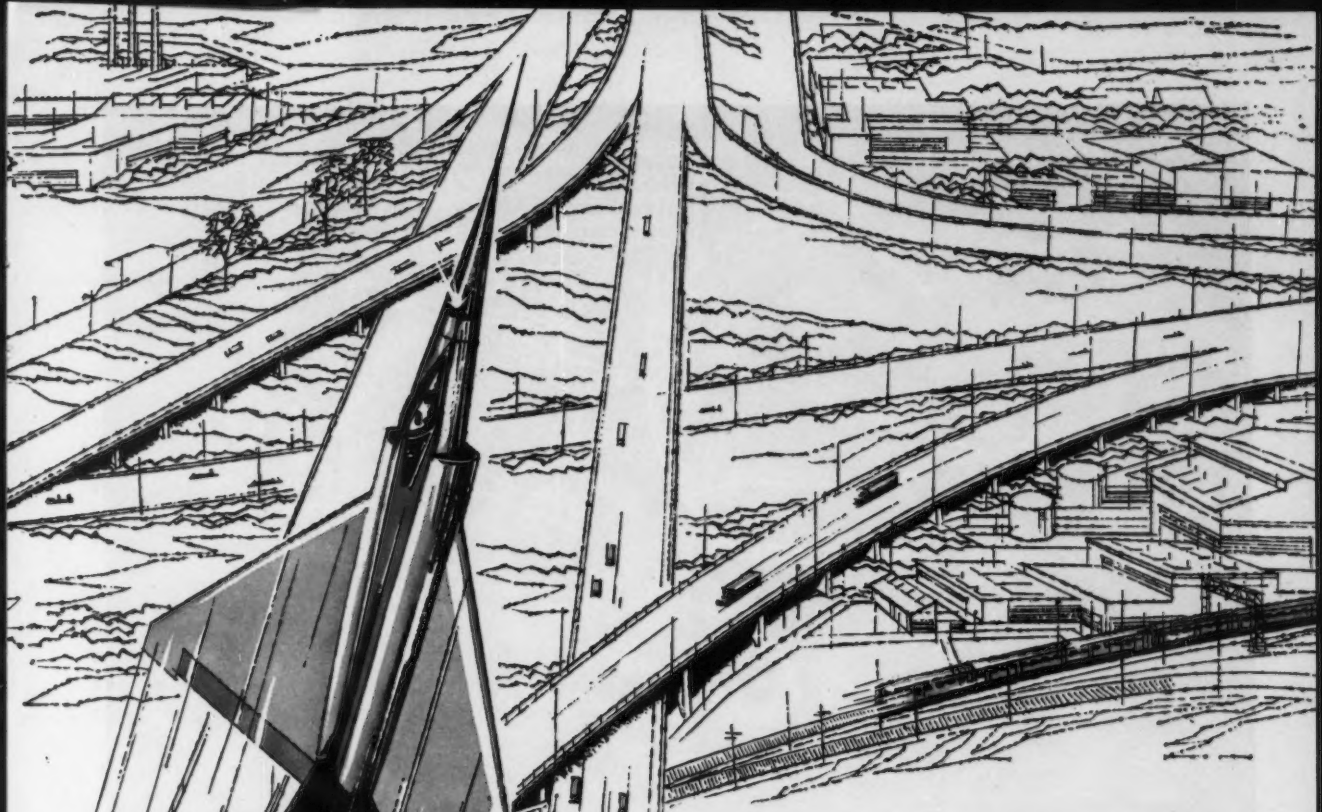

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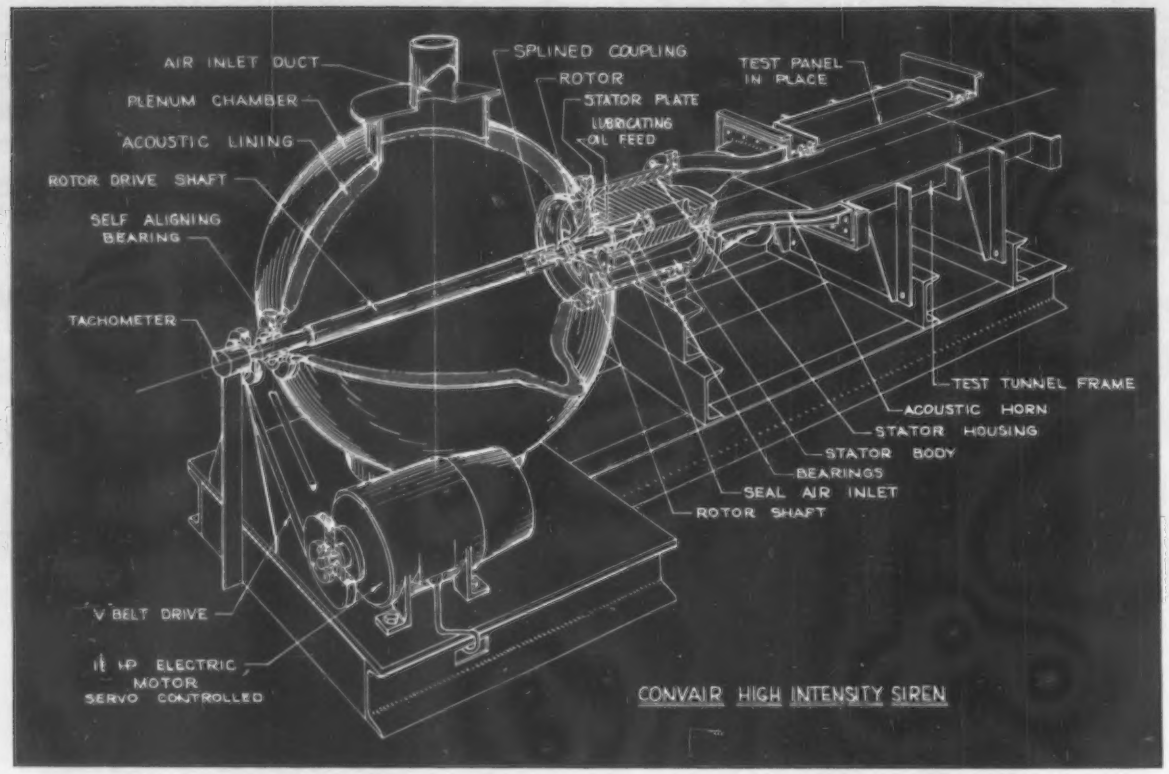


Fig. 1. Overall configuration of Convair's sonic testing facility simulates operational conditions in jet-engine sound field.

design considerations for

a sonic fatigue tunnel

by **R. J. Reid and J. F. Newton,** development engineers,
Convair (San Diego), A Division of General Dynamic Corp.

The effects of intense jet-engine sound fields have aroused considerable interest in sonically-induced structural fatigue.

The danger of fatigue is insidious; although the damage may be developing steadily, it may not be detected until fracture occurs.

The effects of sonic fatigue have been under extensive study at Convair-San Diego. A high-intensity siren, is used capable of powerful acoustic pressure patterns, to provide an accelerated test environment.

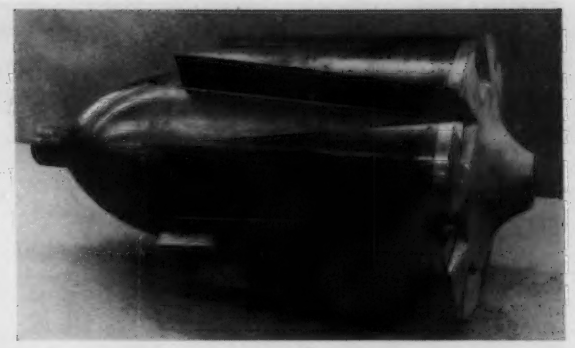
Design goals stressed economy and flexibility of purpose. Basic requirements included frequencies from 50 to 500 cps and sound-pressure levels of at least 165 db (reference 0.0002 microbars), operating into a sonic test tunnel 6 x 22 in. in cross section.

The siren as finally built exceeds these requirements in both frequency and sound-pressure level; it has reached a level of 170 db and more. Amplitude deviation throughout the frequency range is about one db and varies less than this as a function of the spatial coordinates.

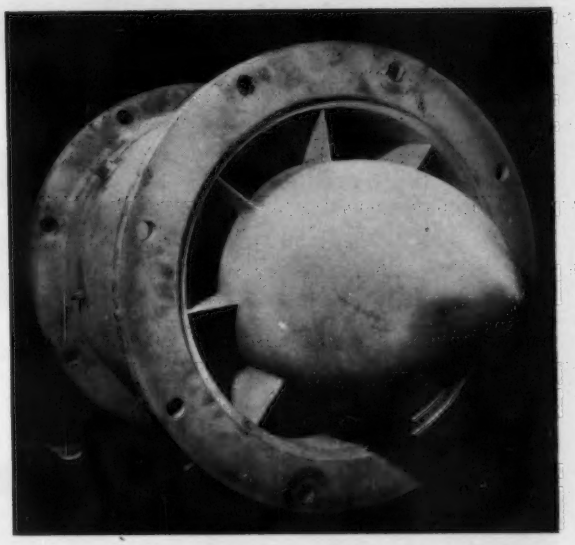
General Configuration

Fig. 1 shows the overall configuration of the test facility. The test panel is shown mounted in a manner simulating a condition on the wing trailing-edge or stabilizer of an airplane. The test panel forms one side of the test tunnel through which the sound passes, thus causing the sound to impinge on the panel at grazing incidence, as is typical of a wing in flight.

Low-pressure-high-volume air is supplied by an Allison auxiliary supercharger of the type originally used to supply air to the Allison V-12 engine. Power for the supercharger is furnished by a 140-hp industrial engine. After traversing the plenum chamber, the compressed air passes through the rotor-horn assembly, converting air-power to sound-power. The acoustically excited air passes through the horn, under the test panel, then into the exhaust tunnel. Most of the sound energy is absorbed in the exhaust tunnel before the air is vented to the atmosphere.



Rotor and internal horn segments can be seen before final assembly.



Stator assembly is seen here from the horn end.

Plenum Chamber

The plenum chamber is a four-foot acoustically-lined steel sphere; it functions primarily to prevent formation of high-energy, high-frequency standing-waves, which might otherwise be excited by the turbine. The volume of the plenum and the connecting pipe comprise a resonant system whose fundamental frequency is so low it cannot amplify the pulses of the turbine rotor. This plenum also provides an impedance missmatch at the rotor in the backward direction, so that sound energy propagates down the horn instead of backward toward the turbine.

Overall Design Considerations

A compromise between desirable and undesirable factors was necessary before arriving at the system's final configuration. Give and take considerations centered mostly about rotor and matching horn geometry. Factors such as orifice size, shape, opening, and closing time, acoustic horn cut-off frequency, and shock-wave loss had to be synthesized with sound power requirements, frequency range, and pneumatic power sources available. Behind all of these considerations was that of providing a uniform sound field in the test tunnel, with a minimum of distortion, transverse standing waves, or local heating.

Rotor-horn-orifice geometry posed a tricky problem. For one thing, total orifice area must be large enough to permit generation of adequate sound pressure in the test tunnel; at the same time, it is desirable that the peripheral length of each individual orifice be small, compared with the wave length of the highest acoustic test-frequency. This would seem to indicate a design with many, small orifices. Such a configuration meant complexity in machining the horn, an increased flow resistance, and a less desirable rotor-port geometry. Orifice shape was considered in regard to the wave shape to be produced. Since the siren was to be used as a discrete-frequency research device, its output had to approximate a sine wave as nearly as practicable. This would facilitate interpretation of results and prevent the use of power in the production of un-wanted frequency components. However, this consideration had to be weighed against the necessity of opening and closing the ports as quickly as possible. This was required to minimize losses due to turbulence. It was also important to have the ports completely closed during the time it took for the negative part of the sound wave to develop.

Port Area Estimation

To estimate the necessary port area, a relationship was needed that gave the sound pressure as a function of the area over which the pressure acted. Such a relationship may be deduced by examining the acoustic field of sound moving through an expanding horn.

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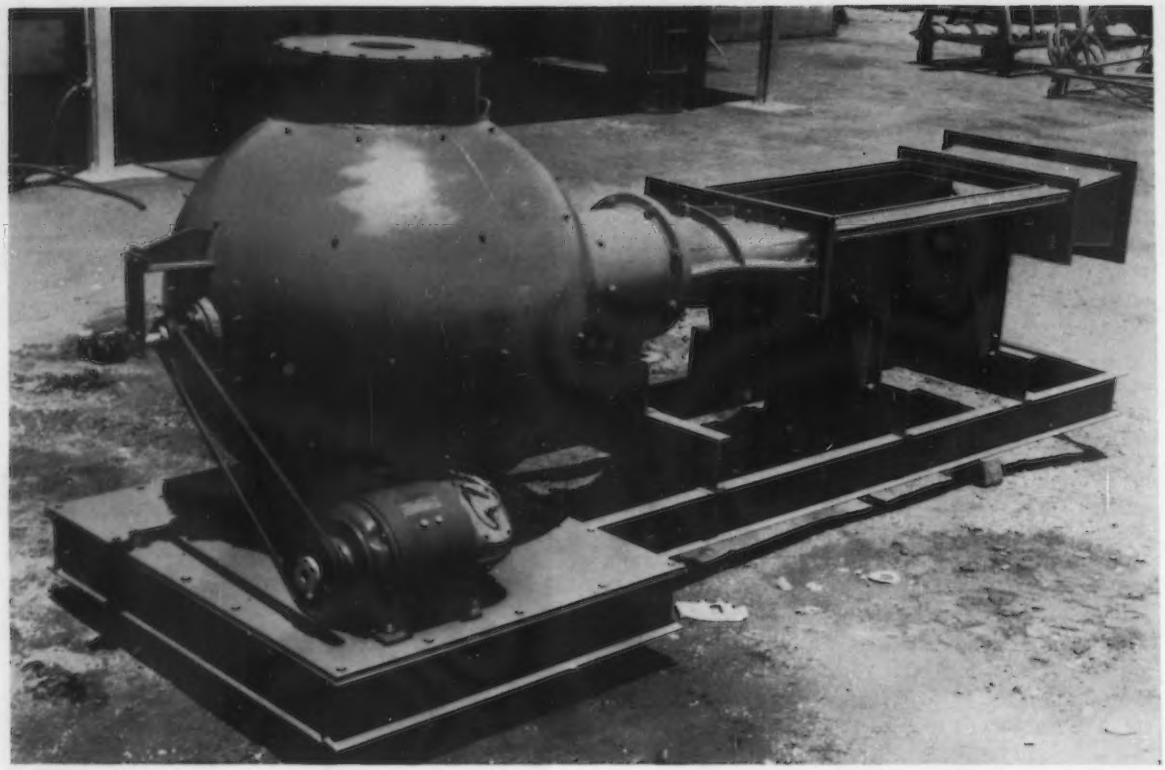
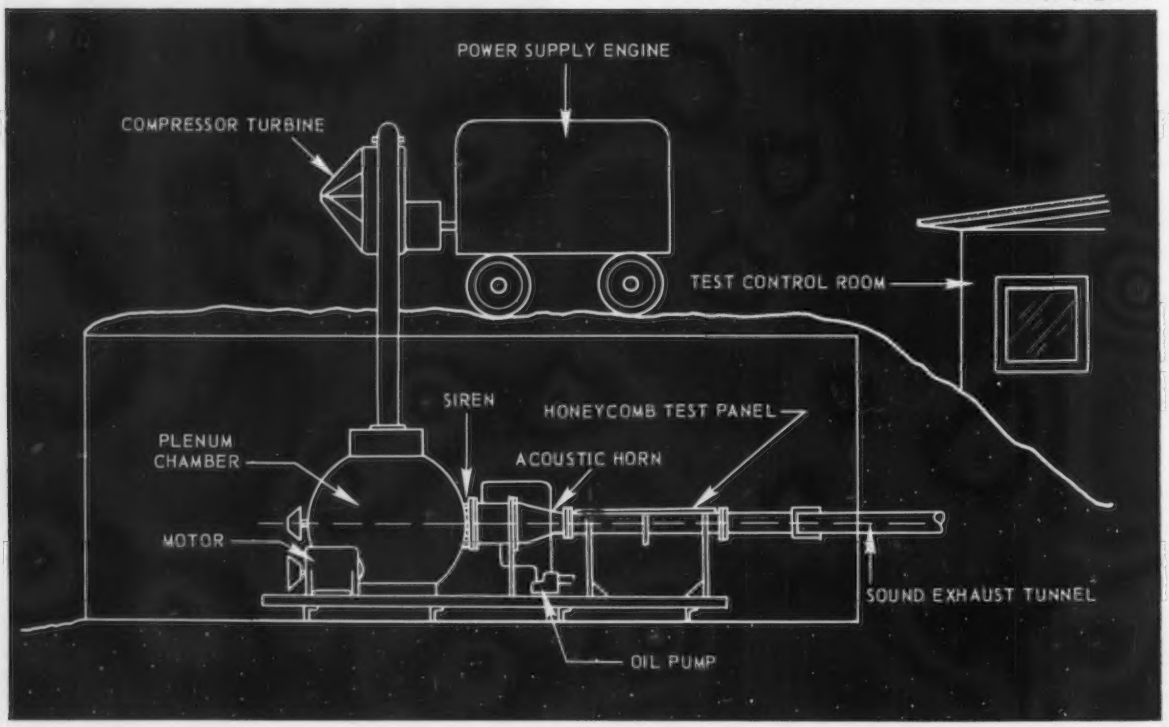


Plenum chamber and horn assembly are displayed before installation. Rectangular opening at right will be closed by a test-panel section.

sonic fatigue . . . continued

Cross section of test site shows location of siren underground to minimize noise propagation.



LIST OF SYMBOLS

S = cross-sectional area
p = r.m.s. pressure
g = efficiency
ρ = density
c = velocity of sound
δ = defined as $\frac{p'}{P}$, or $\frac{p''}{P}$ to which it is equal
p' = gage pressure ahead of shock front
p'' = gage pressure behind shock front
P = ambient pressure
γ = ratio of specific heats (1.4 for air)
x = distance in direction of sound propagation
λ = wave length
S_t = area of horn throat
m = flaring constant
e = base of natural logorithms
p_g = plenum chamber gage pressure
p_a = plenum chamber absolute pressure
A = orifice area
k = wave shape constant ($= \frac{1}{2}$ for square wave)
f_c = cutoff frequency

Note: The subscript o refers to initial condition.

Acoustic energy density is given by the ratio $\frac{p^2}{\rho c^2}$ from which we write the continuity equation, conserving energy:

$$\frac{p_2^2}{\rho c^2} \times S_2 \times c = \frac{p_1^2}{\rho c^2} \times S_1 \times c \times g \text{ or}$$

$$\frac{S_2}{S_1} = \left(\frac{p_1}{p_2}\right)^2 \times g \qquad (1)$$

One might interpret equation (1) to mean that port area can be made as small as one wishes, so long as the pressure is made correspondingly greater. That is a fallacy, since the efficiency, "g," falls very rapidly when pressure is too great. One reason for this is the choked orifice effect. When the ratio of initial-to-final pressure exceeds 1.89, there is no further gain in volume flow for increased initial pressure. The drop in efficiency due to orifice turbulence is also a rapidly increasing function of initial pressure. Finally, there is loss of efficiency due to shock-wave loss, a finite amplitude effect.

Calculating Sound-wave Loss

The formation of shock fronts might be visualized by considering the fact that sound travels faster in denser air. Thus, sound waves starting out in the form of a sine wave gradually become distorted; the peaks "gaining," the troughs falling behind. This eventually results in a sawtooth wave-shape, with sound energy being continually lost in the form of heat across the shock front. Once the shock wave has formed, the following expression from reference (2) predicts the loss sustained by the sound wave as it progresses—

$$\frac{1}{\delta} - \frac{1}{\delta_o} = \frac{(\gamma + 1)(x - x_o)}{2g\lambda} \qquad (2)$$

There was some difficulty in using this expression in the design of the siren for two reasons; first, it was difficult to determine just how long it would take for the saw-tooth to develop; second, in progressing through the siren horn, amplitude is constantly changing. The first was handled by assuming that the shock developed immediately. Although this is admittedly not true, it makes for a conservative design; and actually, at the great amplitudes existing in the horn throats, it is likely that the shocks do develop very quickly. The second difficulty necessitated the extension of equation (2), which presupposed a uniform plane wave, to a plane wave moving through an exponential horn; this was the type of horn chosen for reasons to be discussed later. The relation

$$S = S_t e^{mx} \qquad (3)$$

describes the functional relationship between the cross-sectional area of an exponential horn and distance down the horn. It is possible to combine equations (1), (2), and (3), to get a differential equation for decrease in sound pressure amplitude as a function of distance down the exponential horn. When this equation is integrated, the following expression is obtained

$$\text{Shock Loss (psi)} = \frac{0.858\, p_o^2}{mP\lambda}\left[1 - e^{-mx}\right] \qquad (4)$$

Of particular interest is the fact, obvious from equation (4), that the higher the frequency or the lower the wave length, the greater is the shock wave effect. Also, the smaller "m" is, the greater the shock wave attenuation.

Eight-orifice Configuration Used

The preceding thoughts, along with some consideration of the dynamic stability and structural strength of the rotor, led to the choice of an eight-orifice configuration. The 12-in. diam rotor is divided into eight, similar sectors, each sector covering 45 deg of arc. Each 45-deg arc is divided into a 19-deg open rotor-segment and a 26-deg solid rotor-segment. These rotor sectors operate against the eight horn throats, each covering 14-deg of arc.

continued on next page

The resultant porting geometry gives a condition of full open 11 per cent of the time, full closed 27 per cent of the time, opening 31 per cent of the time, and closing 31 per cent of the time. Outer rotor diam is 12 in., and the total horn throat area is 18.2 sq in.

Acoustic Horn Considerations

It is well known that a cutoff frequency is associated with an exponential horn. This frequency is described by the relationship.

$$f_c = \frac{mc}{4\pi} \qquad (5)$$

This relationship is normally used for horns propagating sound energy arising from vibrating diaphragms or pistons. However, a fundamental difference exists between systems of this type and sirens. In the siren horn, energy is admitted in the form of pressure pulses from the rotor; the sound exists as a progression of pulses and rarefactions passing continually outward from the source. Two experimental observations tend to justify this conclusion. First, no cutoff characteristic has been observed down to about 20 cps, whereas the calculated cutoff by equation (5) should be 57 cps. Secondly, a finite horn of the type used would be expected to give peaks and dips in output, if it were being operated with a piston or diaphragm. No such variations were observed in the siren. Indeed, it seems that the horn used with a siren is not as critical as that used with loudspeakers or other diaphragm type of systems, as long as no reflecting or turbulence-causing discontinuities are built in. The foregoing line of thought lead to the actual horn configuration used, which departs from usual procedures in two ways. First, the horn is considerably shorter, with consequently higher cutoff frequency, than would have been the case had it been designed by classical means.

Secondly, instead of carrying the exponential increase in cross-sectional area right out to the test section, the last three or four inches of horn departed from the exponential increase in favor of fairing smoothly into the test section. It was felt that this would be justified in the decreased turbulence and reflection.

The sonic test tunnel provides mounting for certain types of structural specimens which form one side of the tunnel. The tunnel has a 22 x 6 in. cross section. Most of the siren is constructed of $\frac{3}{8}$-in. thick steel plate.

A sound-absorbing, curved exhaust-system provides attenuation for the acoustic energy after it has passed through the work section. Reflections are minimized by the curving path, enclosed by two-in. thick, coarse, sound absorbing material. After the sound has traversed 14 ft around the $4\frac{1}{2}$ ft radius, it enters a chamber of baffles lined with sound absorption material. Finally, the vent to the atmosphere is reached through a duct of 5 x 12-in. cross-section to achieve least possible radiation area. Sound attenuation of about 40 db is realized at the outlet.

A $1\frac{1}{2}$ hp motor and controller system drive the siren rotor. Good frequency stability is achieved by means of the commercially-available servo-control unit.

While the design described above was primarily intended for use in determining resistance of structual panels to sonic damage, the system is adaptable also to other uses. The siren can be easily operated at lower than maximum levels. Thus, a convenient testing environment may be provided for electronic assemblies and other devices required to operate in high-energy acoustic fields. The siren may be operated as a research device to further study the many other reactions which high-energy sound can produce.

✦

R. Clark Jones, A FIFTY HORSEPOWER SIREN, Journal of the Acoustical Society of America, Volume 18, Number 2, October 1946.

Isadore Rudnick, ON THE ATTENUATION OF A REPEATED SAWTOOTH SHOCK WAVE, Journal of the Acoustical Society of America, Volume 25, number 5, 1953.

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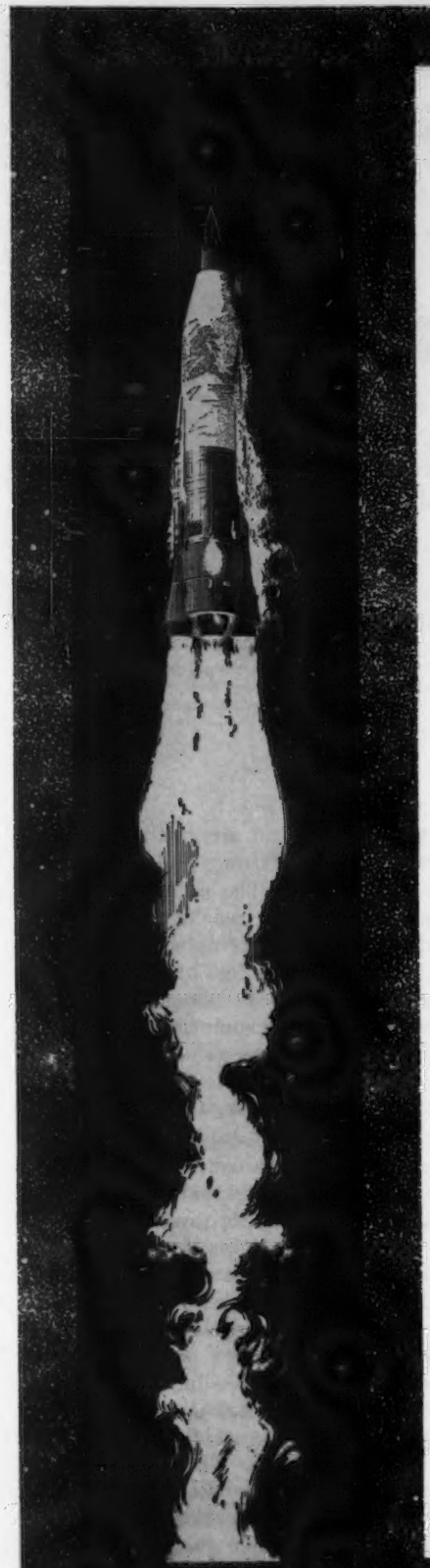

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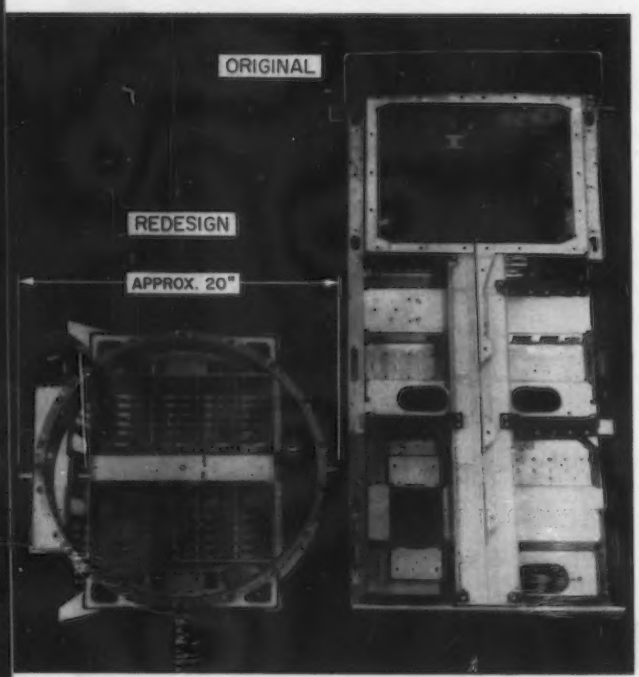
lighter "black boxes"

determined effort by prime, sub, and vendors shaves 31.2 lb from first production design of Hustler's fire-control computer

by **Donald G. Heitert**, chief, physical design
Electronics and Avionics Div., Emerson Electric Mfg. Co.

Decision to pressurize entire unit led to change from rectangular to "sphere-like" housing. Redesign is actually 5-in. sleeve with dome-like covers.

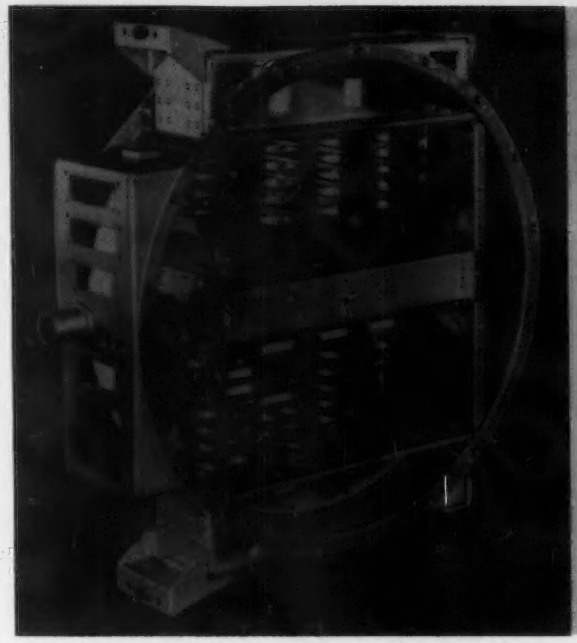


As the complexity of aircraft systems continues upward, more electronic gadgetry will be required to aid the pilot. The point of diminishing returns will soon be reached, however, if weight is disregarded or deemphasized as a design factor. The spiraling effect of excess weight, even in 'light-weight' items, soon takes its toll on fuel quantity, fuel consumption, powerplant size, and aircraft performance.

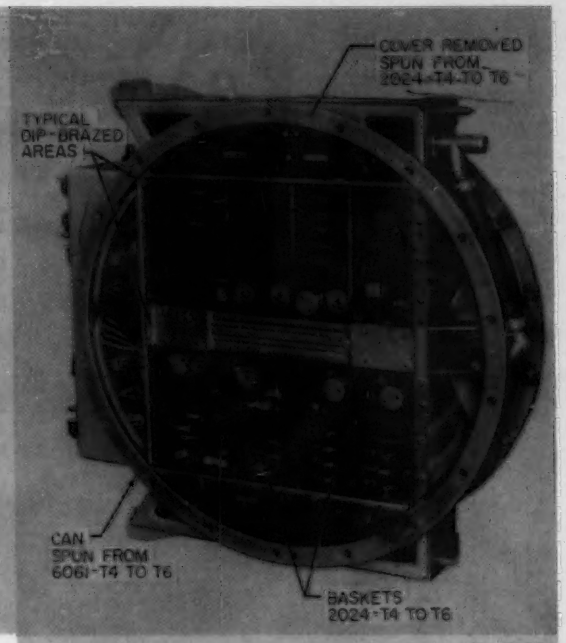
Light Enough Is Not Good Enough

The development history of the analog computer for the B-58 fire control system is an example of how equipment that is considered "light enough" can be made a great deal lighter if time and money are available.

At the design stage, a weight goal of 87 lb was assigned for enclosure, structure, components, and mounting hardware of the fire-control-system computer. With particular attention focused on weight, accessibility, reliability, and ease of manufacture, mock-up and prototype were completed. Prototype weighed in at 88.75 lb, or 1.75 lb over the goal. This was quite acceptable for a first design. Redesign reduced weight of the production version to 75.72 lb. There was an understandable cost in dollars involved, but Convair was willing to accept it. This package was 11.28 lb below the target weight and

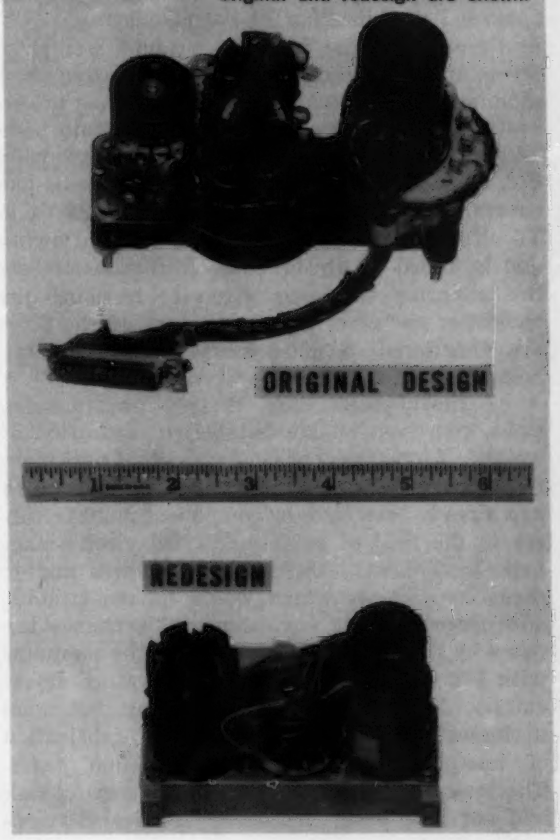


Close examination of structural housing for B-58 fire-control system leaves little doubt to effort expended weight-space reduction. Many of the holes are functional, many "lightening."



Analog computer for B-58 fire control (cover removed) is highly transistorized. Original tube version was 44.3 lb heavier.

Instrument-gear servos represent an appreciable weight concentration; received special attention. Original and redesign are shown.



in some minds it was considered light enough. At Emerson Electric Mfg., light enough was not good enough.

Lose 26 More Pounds

Proposal was made to Convair, and accepted, to chop 26 more pounds from the total weight. This required a radical design departure from vacuum tubes to transistors. State-of-the-art in semi-conductors indicated that this light, electronic package could be made even lighter with equal reliability and performance.

The Reducing Program

The following steps describe briefly how the weight reduction was achieved:

CIRCUIT SIMPLIFICATION was attempted after design and performance were assured by bread-boarding. Minimum number of components consistent with desired circuit parameters was thus assured.

SEARCH FOR LIGHTER COMPONENTS was not limited to government approved types. Where components were found to meet circuit requirements, but were not on the government list, means were sought by Convair, and Emerson to get these components approved.

"CASE-IN-CASE" components were given special attention. By close cooperation with

WEIGHT COMPARISONS—B-58 COMPUTER
Three Designs

Original Design (Vacuum Tube)		Redesigned Vacuum Tube Version		Transistor Version		Difference in lb
Item	Weight in lb	Item	Weight in lb	Item	Weight in lb	Redesign vs. Transistor
Dust Cover	4.9	Dust Cover	2.3	Covers and structure	12.8	
Structure	9.8	Structure	9.1	Heat Exch.	3.6	
Tube Ducts	4.2	Tube Ducts	3.9			
Total	18.9	Total	15.3	Total	16.4	+1.1
Sub Packages	17.5	Sub Packages	17.5	Sub Packages	8.2	—9.3
Connectors	1.7	Connectors	1.7	Connectors	1.7	None
Transmissions	19.1	Transmissions	11.5	Transmissions	4.5	—7.0
Internal Wiring	7.7	Internal Wiring	7.7	Internal Wiring	5.0	—2.7
Misc. Elec. Comp.	6.4	Misc. Elec. Comp.	6.4	Misc. Elec. Comp.	3.1	—3.3
Shock Mtg. Rack	6.3	Shock Mtg. Rack	6.0	Shock Mtg. Rack	1.4	—4.6
Shock Mounts	8.0	Shock Mounts	6.6	Shock Mounts	1.8	—4.8
Insulation	2.0	Insulation	2.0	Insulation	1.0	—1.0
Misc.	1.2	Misc.	1.0	Misc.	1.4	+0.4
Total	88.8	Total	75.7	Total	44.5	Total —31.2

"black boxes" . . . continued

vendors it was possible, in many instances, to eliminate housings for standard components by making the single outer case do the job. Hence, the number of black boxes within black boxes was reduced.

PRESSURIZATION OF ENTIRE UNIT was found economical and feasible. Spherical, or nearly spherical configuration of the housing was generally conceded the best for optimum weight to stress and space ratio. Case was fabricated from aluminum stock because dip brazing was an essential step in fabrication procedure. Main body of the case (can) is a spun 6061-T4 to T6 cylinder, 5 in. long and flanged at each end. Dome-like covers are also spun from aluminum, 2024-T4 to T6. Front "doghouse" is fabricated by drawing and is joined by dip brazing. Illustrations show the attention that was given to reducing the weight of the case. Although many of the holes are functional, a good many are "lightening holes."

INSTRUMENT GEAR SERVOS, or transmissions, represent an appreciable concentration of weight. A great deal of time was spent on weight reduction in this area. Fortunately, much work had already been done by component manufacturers in the field of subminiaturized electro-magnetic components. The big problem was finding those components which would fit the circuits, and operate in the environmental extremes imposed by B-58 (—65 to 190°F inside the computer with 170 to 190°F steady-state operating differential). Not quite as time consuming, but equal in importance, was the design and fabrication of fine-pitch precision instrumentation gears. There were indications that this engineering task had not kept pace with other electrical developments. The subminiature gears used are fabricated from aluminum, anodized to give a hard, wear-resistant surface.

ELIMINATION OF HEAVY POWER SUPPLY components accounted for the most obvious weight reduction in the transition from vacuum tube to transistor circuits. In this particular computer, the power source was not carried in the original package. Therefore, weight saving achieved by eliminating the power supply could not be officially tallied as a computer package saving. Reduction of power requirements also made possible use of lighter wiring in certain areas of the aircraft. Since most of these were external to the computer they could not be tallied as computer loss either. These non-talliable weights amount to 17.5 lb. They boost the total weight saving to the aircraft of 48.5 lb.

"BY-PRODUCT" WEIGHT REDUCTION was achieved through changes in the shock and vibration isolation system. The "tube version" computer system required 88 electron tubes. Since reliability of such systems is affected by poor tube performance, it was found necessary to provide a maximum environment of 2½ G's for the vacuum tubes when the computer was being subjected to specifications inputs from 5 to 500 cycles at a maximum "G" level of 10. Other components within the computer require shock isolation. Therefore, special mounts had to be developed to give both vibration and shock attenuation.

The use of transistors in lieu of vacuum tubes eliminated the necessity of vibration isolation at high efficiencies. It was possible, therefore, to utilize lighter-weight, standard shock mounts with limited vibration attenuation. This resulted in a simple, smaller, and lighter shock mount rack.

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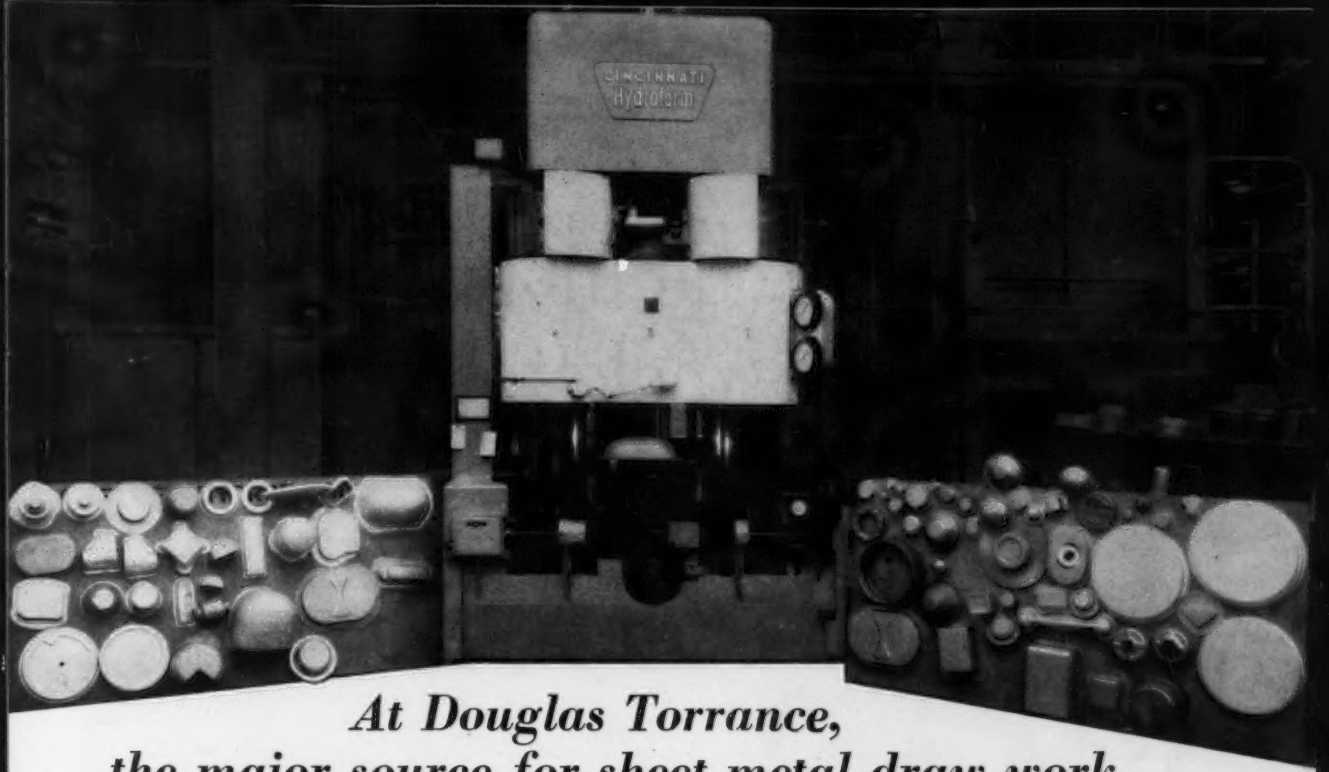

At Douglas Torrance, the major source for sheet metal draw work is the **Cincinnati Hydroform**

The state of Hydroforming art at the Torrance facility of Douglas Aircraft Co., Inc., El Segundo Div., has progressed to the point that their 26" Hydroform® is the major source for sheet metal draw work. The photo above shows their Hydroform, surrounded by display panels of typical parts produced. These display panels are kept at the machine site for the edification of visiting tooling and methods engineers. Note the variety of complex shapes and the extreme range of part sizes, all produced on this machine.

Many parts formerly fabricated by welding and hand finishing, or produced by drop hammer, conventional deep drawing, or spinning, are now Hydroformed complete in one or two draws. Improved part quality, and incalculable savings in tooling and labor costs, scrap loss and production time have resulted.

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CINCINNATI

Small shapes are drawn on the 26" Hydroform at Torrance, by using the ingenious multiple punch and draw ring set shown below. This tooling is used for the simultaneous forming of up to four parts, or for the production of unusually small parts. The main draw ring (Fig. 1) will accept insert-type draw rings, and punches up to 3", 4", 5" and 6" in diameter. Fig. 2 shows a right-hand and left-hand part punch, and draw ring, ready for insertion in the tool set. Tools can be changed in two minutes. Fig. 3 shows the parts produced.

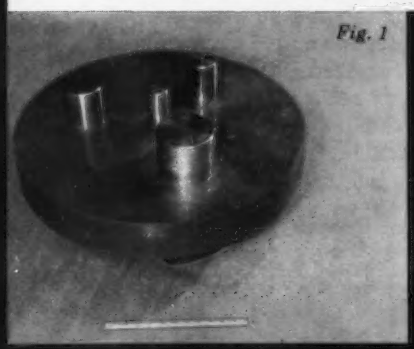


Fig. 1

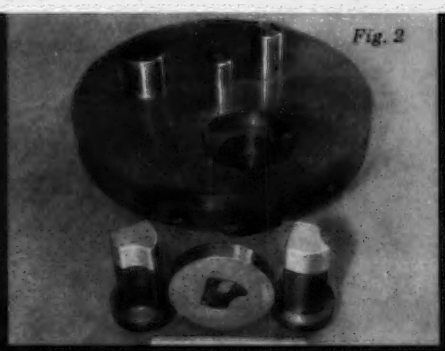


Fig. 2

Fig. 3

filament winding rocket-motor-cases

Minuteman test-hardware fabricated; use of anhydride curing agent for epoxy gives longer pot-life, better strength

Filament winding has been used to produce a variety of plastic motor cases for solid propellant rockets. Size capabilities are 78-in. diam, and 23-ft length on Lamtex Industries Inc. equipment.

The filament winding technique, for producing plastic, solid-rocket-motor cases, is enhanced by the use of special anhydride curing agents.

Lamtex Industries Inc., has made plastic cases with hoop strengths up to 120,000 psi for Nike-Hercules, Bomarc, Little John, Pershing, and Minuteman at one-half the weight of similar structures in steel.

Nadic (National Aniline Div., Allied Chem. Corp.) methyl anhydride,* in an epoxy resin, is impregnated in individual glass fibers and wound onto a mandrel 100 strands at a time. Strands constantly criss-cross from one end of the mandrel to the other. The angle at which individual fibers cross is closely controlled since it affects the percentage of resin in the final product, and the final strength. In some instances, one or two plies of glass cloth are applied over the filament winding to impart a smoother finish, and to better absorb propulsion stresses.

(* *methylbicyclo (2,2,1) heptene-2, 3-dicarboxylic anhydride)*

Anhydride vs. Amine Cure

Several important advantages have been claimed for the anhydride-cured epoxy resin.

- Strength is retained after exposure to moisture.

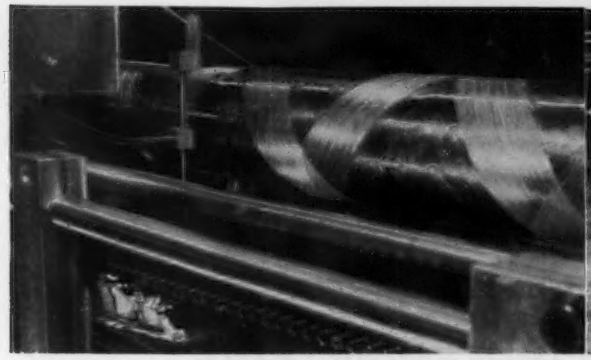
In some other epoxy laminates, water finds its way to the glass fiber and reduces the strength. Good wetting action of Nadic methyl anhydride provides a better glass-to-resin bond. Water absorption is about 0.2 per cent in 49 hr.

- Longer pot-life (about 2 days).

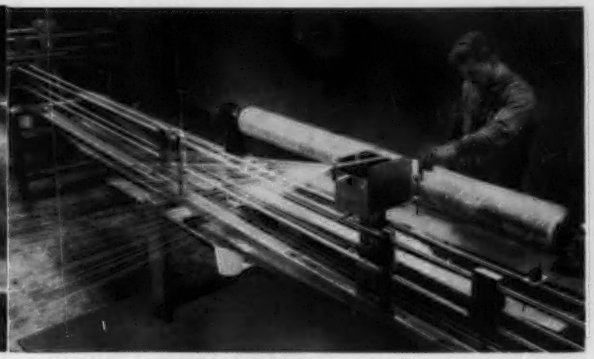
Machinery does not have to be stopped frequently to receive a fresh charge. Danger of having the formulation partially cure on the feed line is also reduced.

- Anhydride is a liquid at room temperature. Unlike many amine curing agents, it does not require melting prior to use.
- Low exotherm reduces residual stresses. Heat distortion point of cured specimen is 200°C, under 264-lb load.

Lamtex can wind cylinders with 78-in. diam and 23-ft length with this material and process. ✦

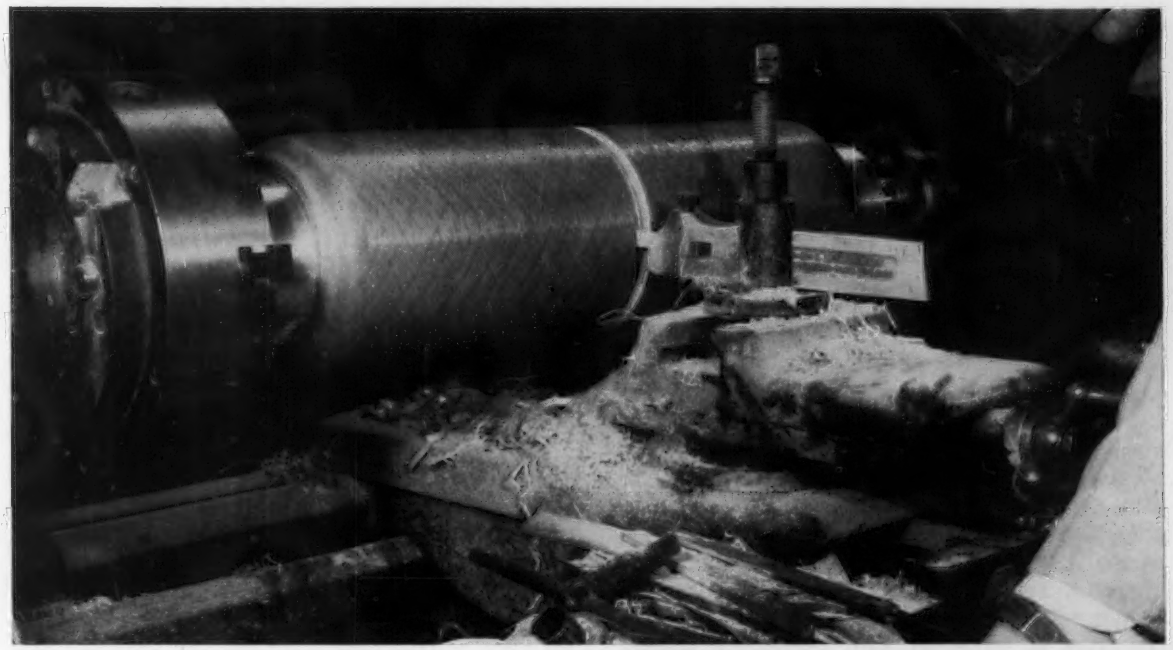


Individual glass fibers are fed from a creel (not shown) into a box containing the resin formulation, then wound on a mandrel.

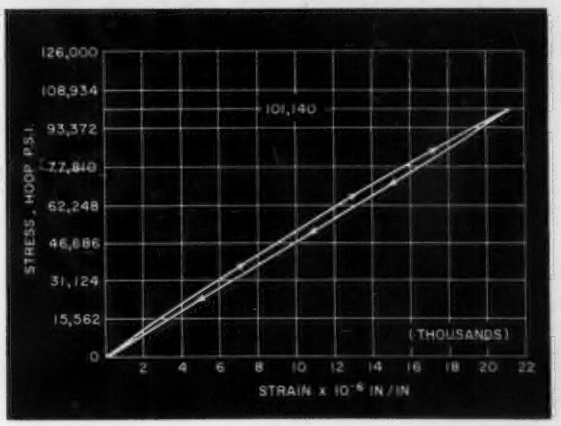


Fibers are criss-crossed on mandrel as feed mechanism is moved up and down track by chain drive. Tension is kept constant on all strands by creel mechanism.

Plastic motor cases are machinable using special techniques. See "machining glass-base laminates," p. 18.



STRESS-STRAIN CURVE
Stress at burst, after cycling to 101,140 psi.



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successful research-rocket

slightly modified Nike booster fitted with ASP as second stage gives NRL reliable, versatile sounding rocket

by R. Bruce Cox
Cooper Development Corp.

ASPAN is a 2-stage upper-atmosphere sounding rocket. Designed and built by the Cooper Dev Corp., it consists of a Nike-booster first stage and an ASP second stage.

It will be used for radiation measurements during sunflares, and for other undisclosed experiments to total approximately 40 flights, during summer and fall.

During the Eclipse Project, when five rounds were fired on board ship in less than one hour, ease of handling and launching were clearly demonstrated.

Design Details—Motor, Igniter

The Type M Nike booster used as the first stage is a solid-propellant rocket motor developed by the Allegheny Ballistics Lab. A special set of 4 bladed fins, designed specifically for use on the Nike when it is flown with light payloads such as the ASP, is substituted for the standard set of 3 fins. The 4 fins are required because of the higher velocities and aerodynamic loads to which the Nike is subjected with the lighter second stage. The standard Nike igniter is utilized. Propellant composition, weights, and performance characteristics are classified.

The ASP motor, or second stage, has a 6.5 in. diam and is 106 in. long. It contains a high-performance propellant having a specific impulse in excess of 200 lb sec/lb, and a total impulse of 31,000 lb sec. It has a tapered bore and a thin-walled steel nozzle with a carbon throat. The nozzle is sealed by a coined copper burst diaphragm which maintains atmospheric pressure within the ASP motor, in order to insure ignition at high altitude.

The ASP igniter is a hot-particle, gasless type in the form of a jelly roll, and is suspended from the forward head of the motor on a fiberglass-phenolic rod. The igniter is initiated by the closing of two barometric pressure switches (there are four switches in series-parallel arrangement); closure of the switches, at approximately 45,000 ft altitude, completes the circuit to an independent airborne battery power supply. The series-parallel arrangement of the switches not only prevents premature ignition of the ASP in the event a switch becomes shorted, but also permits ignition if one switch remains open. The firing circuit is contained in a housing threaded into the forward end of the ASP.

Solid Magnesium Fins

To provide flight stability, the 4 triangular-shaped fins are swept-back. They are of solid magnesium and have a 20-in. span. The trailing edges of the fins are equipped with spin tabs to provide the desired spin rate. The fins are fabricated from solid magnesium, primarily to withstand aerodynamic heating and to insure integrity of their aerodynamic surfaces. The solid fins are cheaper to fabricate than those which are built up. The design of the fins has not yet been optimized from the standpoint of weight; the present design provides the maximum in simplicity and reliability.

Stage Coupling

The two stages are combined structurally by a coupling, which also serves as a fairing between the rockets. The coupling is made from an aluminum casting, bolted securely to the forward end of the Nike, and rigidly attached to the aft end of the ASP motor by means of a threaded separation ring fabricated from ductile cast iron. When the thrust of the Nike booster begins to de-

crease near burnout, an acceleration switch within the coupling actuates two squibs which break the separation ring into halves, thus freeing the ASP. The use of two squibs insures reliable separation, since only one squib is required to fracture the separation ring. The increased aerodynamic drag on the Nike after burnout causes it to fall away, while the ASP continues its coasting flight upward.

Payload Attachment

ASPAN payload, including the nose cone and sections housing the instrumentation, is usually attached to the ASP firing section housing by means of a split ring. This ring permits installation of the assembled payload without twisting or turning, which might damage the telemetering antennas. To date, all data have been telemetered and there has been no requirement for the recovery of either rocket or instrumentation. Payloads weighing 35 to 75 lb are feasible with lengths up to 65 in. Maximum diam is 11 in. for one section; the nominal diam of the payload is 6.5 in.

Aspan Launcher

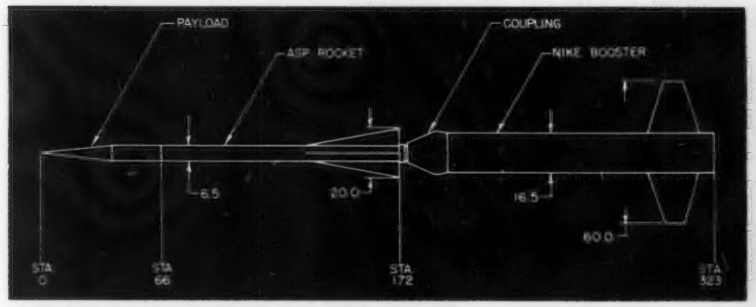
For convenience, ASPAN is always mounted and fired from a Nike launching rail. The launcher is modified to accommodate the 4 fins used on the ASPAN. Outriders on the rail are shortened. Also, some of the hydraulic lines and electrical cabling for the Nike missile checkout are removed.

Firing Circuit

Because of the relatively high resistance of the igniter, a 115v current is used. The firing is accomplished by remote control, and, since this portion of the system is ground based, it can incorporate any desired degree of sophistication without penalizing the performance of the rocket.

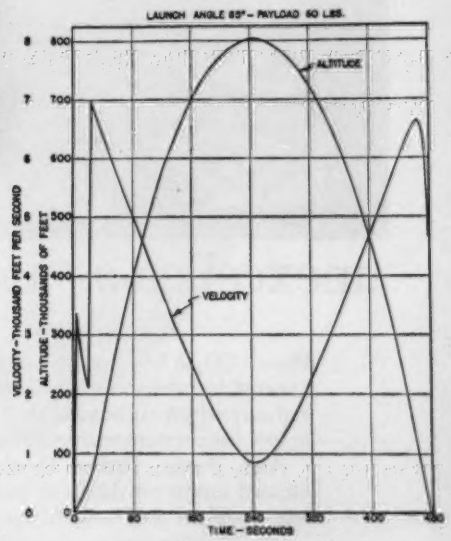
✦

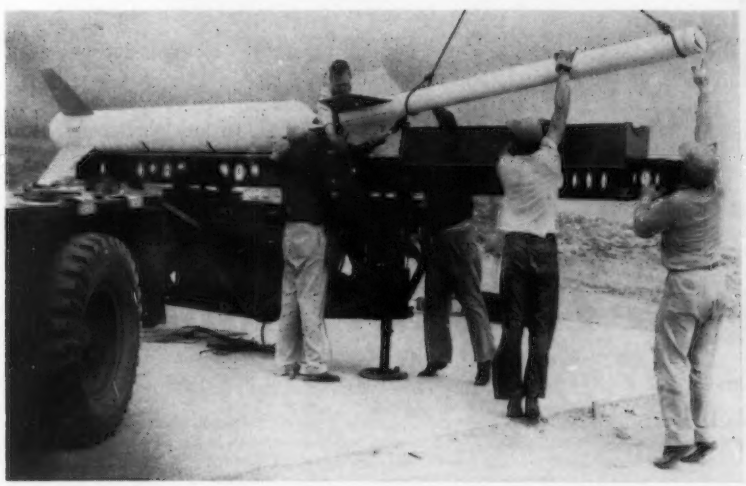
Information extracted from a technical paper presented at American Rocket Society semi-annual meeting, San Diego, Calif.



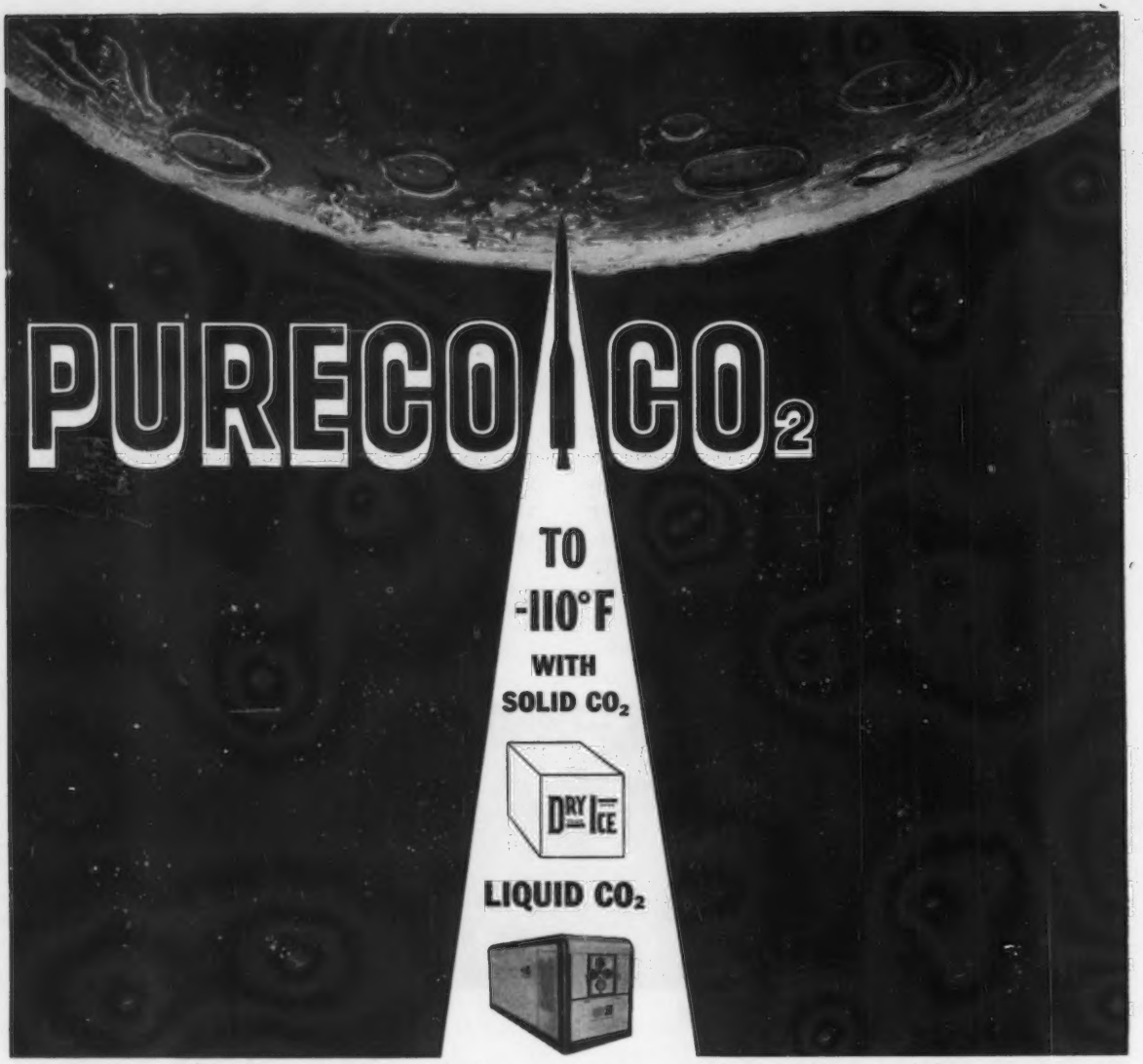
ASPAN rocket configuration. Booster is standard Type M Nike, with set of four fins instead of three. ASP motor has I_{sp} of 200 sec. Nike propellant composition and weight are classified.

Typical ASPAN trajectory





An aluminum-cast coupling is used to secure booster to second stage. Rocket shown here is assembled on "standard" Nike launcher. Nose-cone payload is still to be attached.



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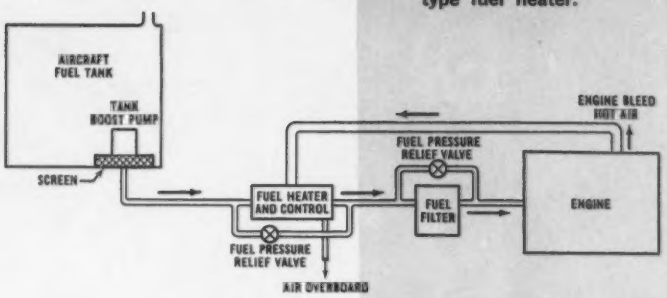
fuel icing



Typical schematic diagram shows fuel system with compressor-bleed-air type fuel heater.

water in fuel systems poses serious flight hazard; airborne fuel heaters prevent ice blockage at critical screen and filter locations

by J. Philip Geddes

On February 11, 1958, a B-52 was making a normal approach to Ellsworth A. F. Base, Rapid City, South Dakota, when power was lost on three engines. The aircraft crashed short of the runway and burned; the fire was rapidly brought under control. An immediate inspection of the wreckage revealed ice blocking the fuel system. From a combination of cold weather and prompt action, the first case of failure through fuel icing was proved.

Fuel icing has caused a number of turbojet engine power failures—some with disastrous results. Several unaccountable accidents happened to military jets before fuel icing was even suspected.

Lab tests have since shown that when jet fuel cools within the temperature band of +20 to −20°F, moisture present in the fuel forms ice slush. This slush builds up rapidly on tank walls, screens, and filters; fuel starvation generally follows.

Water in Fuel

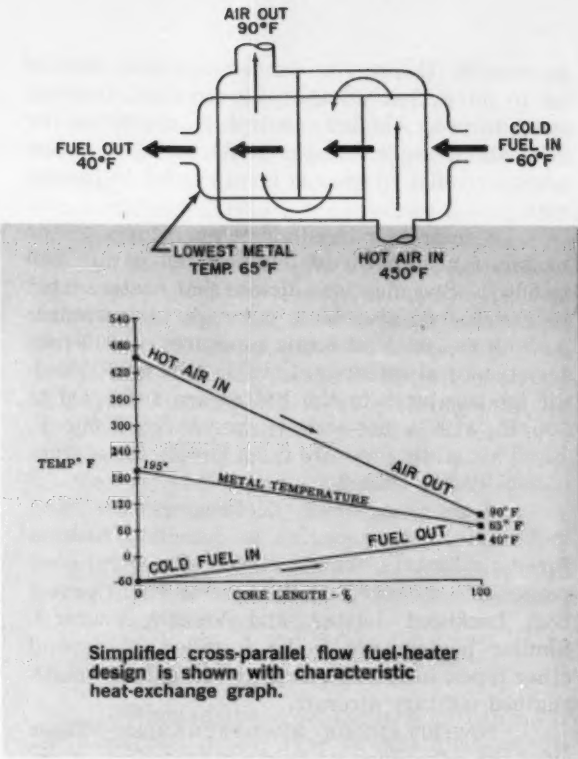
Water can be present in fuel in three different forms: free, entrained, and "dissolved." This water can find its way into the fuel during manufacture, but collects mainly during transportation and storage through condensation. Such water can be easily drained from tank sumps.

Entrained or emulsified water is in suspension and distributed throughout the fuel. Recently-developed filters can separate some of this water during refueling, then it can be drained off as free water.

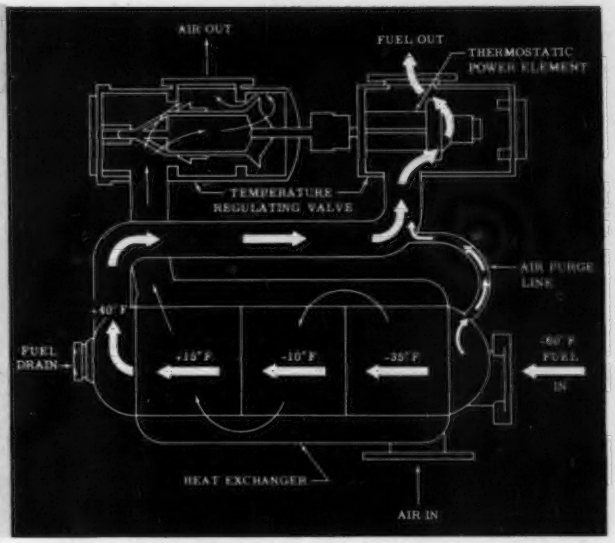
Water in solution with the fuel, "dissolved," is difficult to remove on the ground, and is impractical to eliminate in flight.

Flight Problem

Fuel absorbs and retains moisture in much the same way as water vapor is held in the atmosphere. When an aircraft flies through moist air, the mass of fuel aboard cannot be prevented from absorbing some of this moisture. The short flight duration of fighter aircraft reduces this



Simplified cross-parallel flow fuel-heater design is shown with characteristic heat-exchange graph.



Typical bleed-air fuel-heater incorporates modulating air-flow control system.

type of contamination. But, even fighters become fuel-ice prone after filling up from aerial tankers.

Anti-Icing Precautions

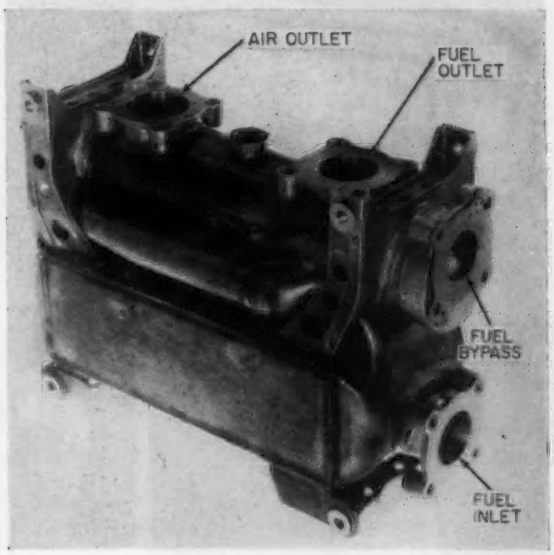
Since at present it appears that water cannot be completely eliminated from fuel systems, anti-icing systems are being incorporated. Tests reveal that screens and filters are the most critical ice-buildup points. Various filter fixes have tried to minimize effects of ice buildup. Screens have been removed or enlarged, bypasses and relief valves added, filter densities lowered. The results? The icing problem is transferred to the engine fuel controls.

The de-icing approach, instead of anti-icing, saw the application of alcohol injection systems to critical filters. Drawbacks in such systems are weight penalty, and that effective action is taken only after the icing has occurred—this may be too late.

Fuel Heaters

Since temperature at which water in fuel forms ice is below about +20°F, the most obvious

AiResearch bled-air fuel-heater features all-stainless-steel construction.



remedy is to heat the fuel to above the critical temperature, immediately before entering engine. Generally, fuel heaters are in fuel lines, just before the low-pressure filter. Fortunately, icing is not critical around the tank booster-pump area, although ice slush may also form in fuel tanks.

Fuel Heater Designs

AiResearch Manufacturing division of the Garrett Corp., among other companies, has developed a series of fuel heaters. These heaters are of two basic types: (1) where hot air bled from engine compressor is the heat source, and (2) where heat is derived from powerplant lubricating oil systems.

COMPRESSOR-BLEED-AIR HEAT-EXCHANGERS. AiResearch compressor-bleed heaters take air from engine on a "when required" schedule. Once circulated through heater, air dumps overboard. Fuel flows through heater at all times. When maximum fuel heating is required, approximately one-half per cent bleed air loss is experienced at engine. Thrust losses are minimized by regulating bleed air flow with an automatic flow control built into heater. The flow control senses heater-exit fuel-temperature and modulates accordingly by partially opening or shutting off the hot bleed-air supply. Heater fuel out-temperatures band of 35 to 50°F, but always above critical freezing temperature. Air-flow control is unaffected by inlet air-pressure changes or fluctuations. A fuel pressure relief by-pass is incorporated in the design.

Compressor-bleed-air temperatures to the heater, for high thrust engines, fall within 300 to 600°F. Specifications dictate that heaters must be capable of absorbing hot-soak temperatures as high as 760°F at static pressures of 300 psig for structural integrity. Low-thrust engine-bleed-air temperatures to the heater are from 200 to 500°F, with a hot-soak temperature of 600°F. Bleed air static pressure from low-thrust engines is usually less than 200 psig.

Compressor-bleed fuel-heaters are normally mounted on engine or nacelle structure. Bleed-air heaters, manufactured by several companies, are mounted on the Boeing 707, Convair 880, Lockheed Jetstar, and Vickers Viscount. Similar heaters are to be installed on several other types, including retrofit on single and multi-engined military aircraft.

POWERPLANT-OIL HEAT-EXCHANGERS. These offer the advantage of being independent of engine hot air sources. Their main drawback is that

Pressure-test bell (fish bowl) is used to detect under-water leakage visually. No leakage is allowed.

AiResearch combination of fuel heater, oil cooler, and fuel strainer on Douglas DC-8 is completely independent of compressor-bleed-air heat source.

installations are limited to systems where sufficient heat is available from powerplant oil. Generally, oil fuel-heaters are located in engine lube scavenging system, in series with, but before the ram-air oil coolers. In the AiResearch design, an automatic modulating control senses heater fuel-exit temperature and directs hot oil around or through the heat exchanger core, as required. An oil-by-pass provision is also included to prevent fuel overheating. Fuel flows through heater continuously. Oil temperatures to heater are from 200 to 250°F. Tests revealed that air entrained in engine-scavenge oil, flowing through the oil fuel-heater, caused an increased pressure drop across the heater of 30 per cent or more above air-free oil performance. Due to this pressure drop, flow area in oil fuel-heaters must be increased a corresponding amount.

Oil system dependent fuel heaters of differing designs are installed on the Lockheed Electra and Douglas DC-8.

Fuel Heater Design

Design of fuel heat-exchangers can be of the shell-tube-bundle type or the plate-and-fin extended-surface type. AiResearch's shell-and-tube-bundle design oil coolers have been in service for many years with established reliability. This basic cooler design has been applied in reverse to make a fuel heater—now the hot oil heats the cold fuel and is cooled in the process. Fuel flows inside the tubes, and oil flows over and along the tubes, to oil cross-baffles.

While existing oil-cooler designs have been modified for oil fuel-heater applications, there has been no similar practice with bleed-air fuel-heaters. Simultaneous application of fuel at −60°F and compressor bleed air at 600°F subjects fuel air-heaters to severe thermal stress. Thermal stress in combination with high air pressures and near-sonic air velocities through heat exchanger, create severe problems in structural design. Rugged heater construction is a must, since structural failure could spray fuel over the hot engine.

Materials

Selection of materials for fuel-heater design is dictated by operating temperatures, pressures, and installation environment. An airframe manufacturer may specify a heater fire resistance requirement of 2000°F. Bleed-air soak temperatures may be as high as 760°F. Fuel heaters mounted directly on engines are exposed to high surrounding temperatures. AiResearch bleed-air heaters are made of stainless steel. In plate-and-fin construction, fully-supported heat-transfer surfaces are provided throughout the core by brazing contact surfaces of fins to the separation plates. Brazing the core helps compact the design by providing a rugged box structure.

Thermal Design Considerations

The number of possible fuel-flow and oil or air-flow conditions, in combination with fuel and air temperatures, which may be encountered in flight, is almost infinite. The engine or airframe project engineer is therefore faced with a difficult problem in detailing heater performance requirements. He has to select a series of design points which in his best judgment appear to be "typical" and "critical" flight-performance conditions.

The heater must be designed to be ice-free on both cold and hot sides. To achieve this, heater specifications must make it mandatory for all heat-transfer surfaces to be maintained above water-freezing temperature. In thermal design, the engineer determines the flow path between fuel and heat source in heat exchanger. With the possibility of localized fuel boiling, fuel icing, ice slush pile-up at "off-design-points," an apparently-simple problem becomes difficult.

From study of many possible flow combinations AiResearch concluded that to prevent heater icing, particularly at the almost infinite number of possible off-design points for bleed-air-to-fuel heaters, the hot-to-cold flow arrangement must incorporate cross-parallel flow.

Commercial and Navy fuel-heater performance specifications have required heating the maximum engine-fuel flow from a temperature of approximately −65°F, −40°F, −30°F, or −10°F, depending on aircraft operational characteristics. The Air Force requires a heater-inlet fuel-temperature of −65°F.

Permissible heater-fuel pressure-drop is between one to two psig (at maximum engine fuel flow) so engine operation will not be severely affected in the event of fuel-tank boost-pump failure.

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"ultrasonic image camera"

device developed for medical use shows potential in inspecting for "hidden" flaws in metals; no radiation dangers involved

by Ronald A. Cole

A method of inspecting the interior structure of metals, without using hazardous X-rays, has been developed at University College Hospital in London. Originally proposed for medical use in examining human bones, there is now hope that commercial interests will take up practical development and marketing tasks.

Method makes use of an "ultrasonic image camera," and would be complimentary to established ultrasonic pulse-echo methods of inspection.

"Ultrasonic image camera" was developed at University College Hospital, London. Prototype indicates potential for industrial use.

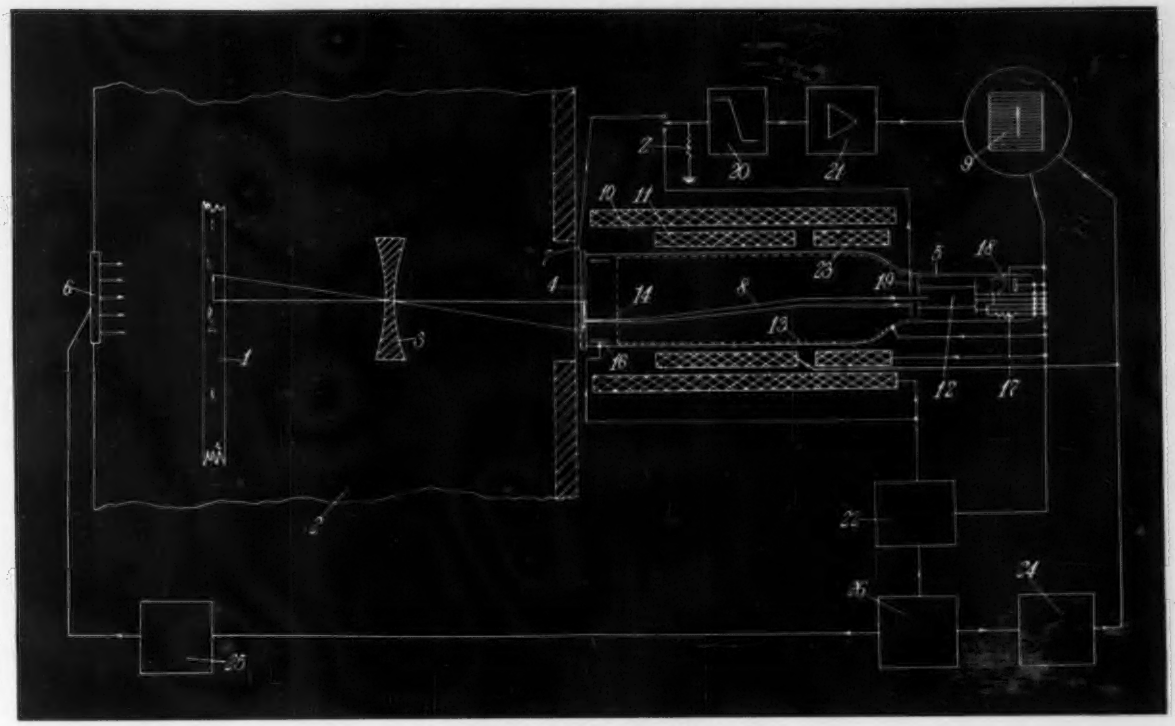
Before detailing a description of the apparatus it should be remembered that the original hardware was constructed in the workshops of colleges on meager resources. More sophisticated setups could easily be made with capital outlay not out of proportion with that used in developing other nondestructive test machines.

How It Works

The basic principles can be understood by thinking of the way one can see through clear water. This is possible because light waves pass through the water. In a similar way, sound waves will pass through solids, and this makes it possible to see the reflected sound waves as an image on a television screen.

More exactly, the principle of the "ultrasonic image camera" works in the following manner. The object to be inspected is immersed in a continuous-wave ultra-sound field. The sound is then diffracted by the object and the diffraction pattern is formed on a single piezo-electric plate. This plate is arranged as the end wall of a scanning electron tube similar to that in a television camera. A typical arrangement used is to have an uncoated X-cut quartz crystal as the piezo-electric plate. This is of one in. diam and has a half-wave resonant thickness of 4 million cycles/second.

The ultra-sound vibration image falling on the quartz crystal produces a corresponding alternating piezo-electric voltage distribution



OPERATIONAL SCHEMATIC

1. Object under examination.
2. Water tank.
3. Acoustic lens.
4. Quartz crystal. 0.7 mm thick, 1 in. diameter.
5. Glass envelope of camera tube.
6. Ultrasonic source.
7. Signal output electrode. (Metal foil between tank and quartz crystal covered by Terylene plastic foil to prevent water reaching camera.)
8. Scanning electron beam.
9. Picture reproducer.
10. Focusing coil.
11. Deflector coil.
12. Electron gun.
13. Metallized coating.
14. Ion-trap mesh.
16. Conducting ring.
17. } Titanium ionization pump.
18. }
19. Electron gun anode.
20. Pre-amplifier.
21. Signal rectifier (only used with collateral cathode stabilization, not used with cathode potential stabilization.)
22. Scanning generators.
23. Alignment coils.
24. Flyback blackout circuit.
25. Ultrasonic generator.
26. Electronic switching circuit for controlling picture reading.

across its surface. The magnitude of this is read from point to point by the scanning electron beam. Thus the camera produces an output current proportional to the incident ultra-sound intensity. After amplification the output modulates the brightness of a television reproducer which is scanned in sympathy with the camera. In an arrangement tested, the tube is magnetically deflected and focused while the internal surface of the crystal is scanned to give cathode-potential stabilization of that surface.

Working at 50 lines/centimeter and 50 frames/sec, the ultra-sound illumination is switched on for alternate frames only. Thus between each frame there is a change in charge distribution on the quartz and the picture can be reproduced repeatedly and moving parts followed. The surface of the quartz becomes negatively charged from the arrival of electrons during positive half cycles of the piezo-electric voltage. It is then returned to cathode potential by the arrival of positive ions.

To date it has been possible to detect flaws in blocks of metal, cracks in welds and non-attachment of thin platings. Sensitivity has also been good enough to see the skeleton of a fish while swimming in a tank of water.

While the basic design and technical operation of the camera has been proved there are still many problems associated with development that will make it a practical everyday tool. For instance the camera-sensitive surface is at the end of a vacuum tube therefore its size is limited by the ability to withstand external pressure. If the tube end is made thicker picture resolution decreases and it is in fact better to employ lenses of greater magnification.

✦

fail-safe testing the 880

designers assemble crack initiation and propagation data on Convair jet airliner; fuselage sections subjected to 50,000 pressure cycles from zero to 8.6 psi

by J. E. Gillette, test engineer
Convair-San Diego

To obtain protection against fatigue-cracks and explosive decompression, Convair 880 utilizes a heavy fuselage-skin. This design concept takes advantage of the fact that it is possible, within limits, to take weight from sound proofing material and add it to the fuselage skin without loss of noise attenuation.

The number and size of fuselage stringers is also reduced, and the resultant weight saving is invested in heavier skin gauges. The Convair 880 fuselage has a minimum skin thickness of 0.060 in., for a maximum gross hoop tension stress of 8,500 psi at 8.2 psi normal cabin operating pressure. Hoop tension stress is believed to be lower than that of any pressurized transport now in service. Fatigue cracks will, therefore, probably not exist throughout the life of the airplane. Completed tests described herein bear this out.

Two Phase Program

All fuselage skins are made of 2024 aluminum alloy. This alloy has high resistance to fatigue crack initiation and propagation.

To determine fuselage fail-safe qualities a test program was set up which consisted of:

- Applying 50,000 pressure-cycles at cabin operating pressure to test sections (one pressure cycle represents one flight of the airplane).
- Initiating cracks in skins, and measuring the rate of crack propagation.

Test sections were representative of structural arrangements in different areas of the cabin. At the time of this writing, testing of sections representative of the nose landing gear wheel well, the lower fuselage shell, a half section cut at the vertical center-line, the upper

fuselage shell, and structure in the baggage compartment door area had been completed.

Problem—Simulating Loads

In testing the fuselage half section, it was desired to apply longitudinal stress simultaneously with hoop tension stress. This posed a problem, since the test section-to-fixture attachment had to withstand cabin operating pressure and, at the same time, let the section elongate so that the desired longitudinal stress could be attained.

This problem was solved by using a "floating end" which allowed the test section to extend when internal pressure was applied. Longitudinal stress was induced by hydraulic rams attached to the floating end. Internal pressure was maintained by a neoprene strip attached from the floor of the test fixture to the floating end plate.

The nose-gear wheel-well section was loaded by adding a fourth side to the three flat panels, thus forming a box. The box was evacuated from atmospheric pressure to minus 8.6 psi, simulating the maximum cabin differential pressure acting on the outside of the box. The box and cycling mechanism are illustrated.

"Accidental" Cracks

Saw cuts were made in the skin of the sections to simulate accidental damage. In order to improve the simulation of cracks, the saw cuts were "sharpened" by tapping a knife blade inserted at each end.

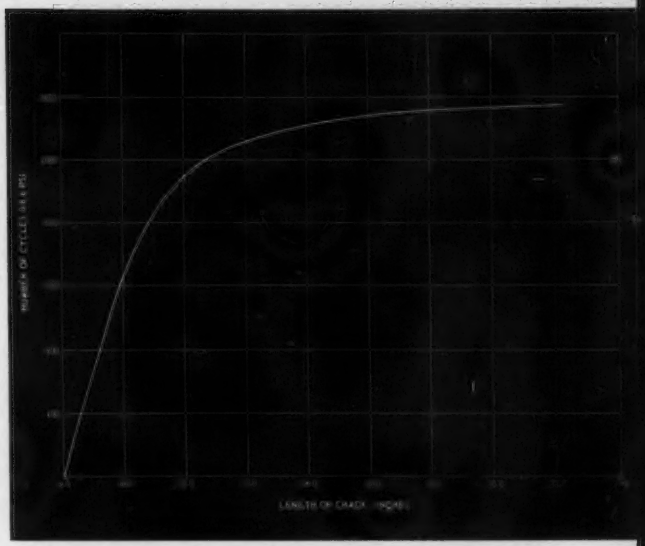
Saw cuts were made in the first lower shell section at the following locations: (1) midway between belt frames and stringers, (2) over a belt frame, and (3) over a cut belt frame. The section was pressure cycled with water from zero to the maximum cabin pressure of 8.6 psi.

Comparative Crack Growth

Curves of the crack propagation were plotted during the tests. A typical curve of crack length versus number of pressure cycles is shown. Note that the curve becomes nearly asymoptotic as the crack extends. The running plots were used as a guide to aid in determining how long a crack would propagate before rupture might occur. Crack growth was measured at 50 cycle intervals using dividers and a steel scale.

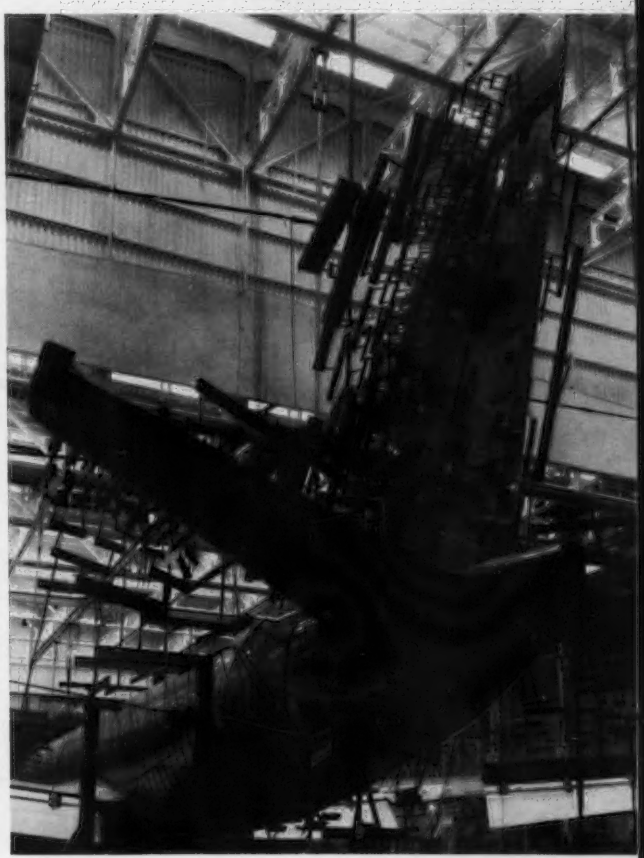
The same test was repeated using an air pressure cycle over water to determine if air escaping through the crack would affect the rate of crack growth. The escaping air had no effect on the rate of growth.

All further testing of the fuselage shell sections was accomplished using an air cycling



Curve with typical crack length vs. cycles characteristics. Curve becomes nearly asymptotic as crack extends.

In tests other than those described in text, 880 fuselage is subjected to simulated aerodynamic loading. Loads are applied by hydraulic rams through "wiffle tree" arrangement.



system with the sections nearly full of water. This produced a faster cycle rate and minimized the volume of air within the sections. Checks were made to determine if high cycle rate had an effect on the rate of crack growth by comparing a 15-sec cycle to a 3-sec cycle. No difference in growth was observed.

The second lower shell section tested contained intercostals attaching the skin to the frames between stringers. This construction is typical of production airplanes. Both sections had a skin thickness of 0.063 in., with 19-in. belt frame spacing and 6-in. stringer spacing.

Rate of crack growth during tests of the second section was essentially the same as the first, until the crack approached the intercostals. At this point the growth rate decreased and the cracks stopped at the intercostal rivets for several cycles before extending beyond.

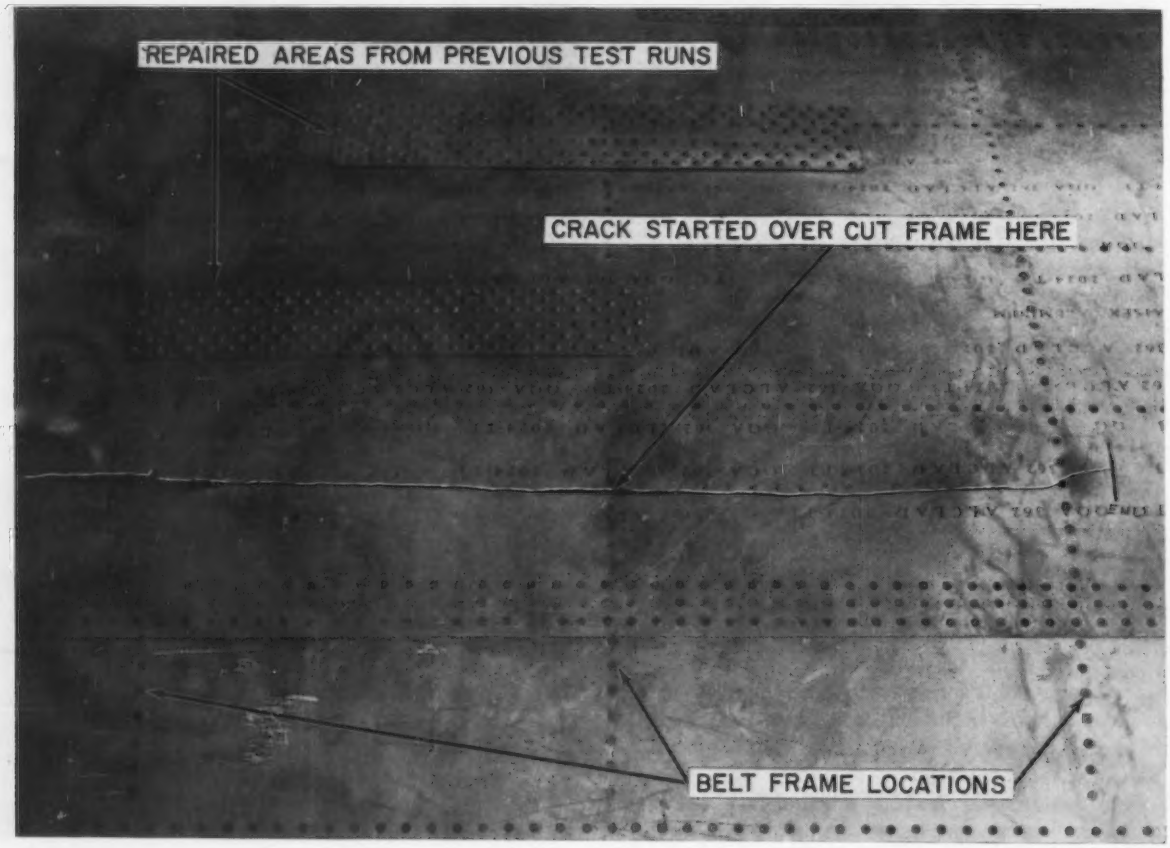
Illustrated (lower right) is a crack which was started over a cut belt frame and extended beyond the adjacent frames to a length of 41.9 in. Application of the final cycle caused the crack to grow from 41.9 in. to 54.4 in. A total of 4,300 cycles were required to promote growth from 4.0 in. to the final crack length.

A saw cut was also made through the end rivet in an intercostal and along the high-stressed rivet row of a skin splice. Crack growth in these areas was at a very slow rate. The crack pattern in the rivet row is also illustrated. Rivet spacing is 1.00 in.

No Cracks After 50,000 Cycles

The height of the fuselage half section made it necessary to compensate for the weight of water inside, which produced 2.5 psi pressure at the base of the test fixture. This was accomplished by enclosing the test fixture, forming a water tank. The half section contained four "floor beam-to-belt frame" attachments and two cabin window installations. Fifty-thousand (50,000) pressure cycles from 0 to 8.6 psi were applied, with frequent inspections for fatigue cracks. No cracks were found after 50,000 cycles.

Crack started over cut belt-frame extended to a length of 54.4 in. after 4300 cycles were applied.

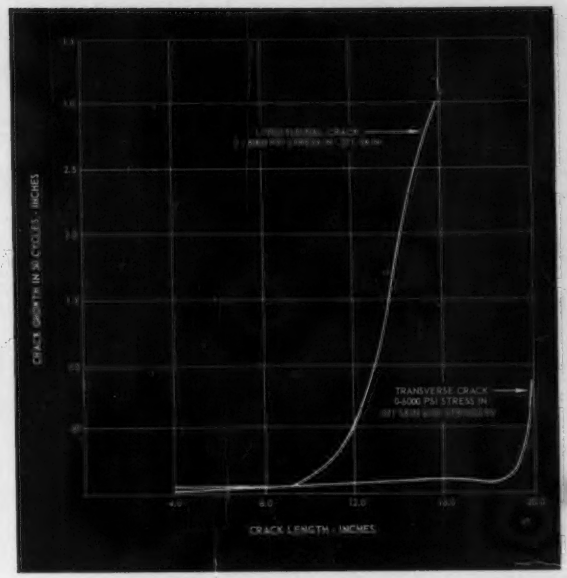


An additional 30,000 cycles from 0 to 9.3 psi were applied.

The fail-safe tests on the half section consisted of imposing damage in areas of the cabin windows and "floor beam-to-belt frame" attachments. Cracks also were initiated across stringers (transverse cuts) with end loads being applied to produce 6,000 psi longitudinal stress simultaneously with 8,000 psi hoop tension stress, as measured by strain gages glued to the skin in the test areas.

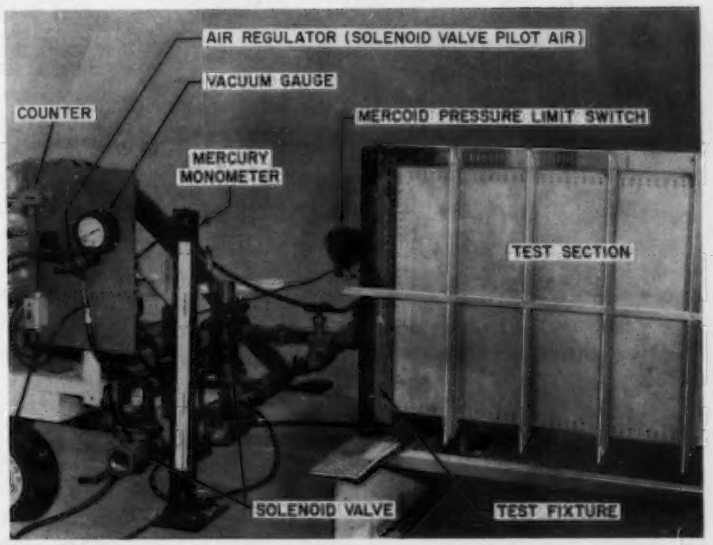
Growth rates of cracks in the transverse direction were slower than for longitudinal cracks initiated normal to hoop tension loading. A comparative plot of crack growth in these two directions is illustrated. The final test of the half section involved pressure cycling with a cabin window frame cut through at a corner radius. No crack growth in the skin occurred when 2000 cycles were applied.

The saw cut was then extended ½ in. in the 0.071 skin. This produced crack growth which extended to the adjacent window and sheared the rivets on the lower side of the win-

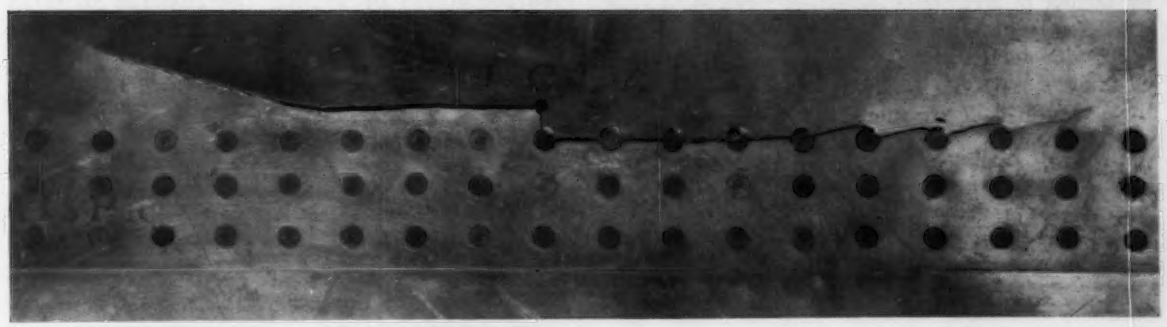


Plot shows comparative transverse and longitudinal crack growth on fuselage half-section (lower).

Cycling mechanism is shown affixed to box representative of the nose landing gear wheel well section.



A saw cut was made along the high stressed rivet row of a skin splice. Crack growth in the area was much slower than where the skin was able to "lip up" on both sides of the crack.



dow frame after 1900 cycles had been applied. An additional 100 cycles were applied with no further crack growth occurring.

Nose Wheel Well

Test of the nose wheel well consisted of applying 50,000 cycles from atmospheric pressure to —8.6 psi, followed by fail-safe tests with imposed damage. Again, no fatigue cracks were found after 50,000 cycles. No longitudinal progressive cracks were obtained in this section when the four frames were cut, and the skin cut to a length of 36 in. Crack growth in the transverse direction was at a very slow rate until the crack approached the sides of the section. Total crack length was 30 in.

Upper Fuselage

A section representative of the upper fuselage shell in the area of maximum bending moment was subjected to repeated applications of the maximum stresses for a typical flight. (Stresses resulting from 1.3g loading plus 9.3 psi fail-safe cabin pressure.)

Cracks were initiated in the skin across the stringers (transverse cracks). This test was followed by applying the maximum design fail-safe stresses to the test section. (Stresses produced by 2g loads plus fail-safe cabin pressure.) The maximum design fail-safe stresses consisted of 6,400 psi hoop tension plus 22,000 psi longitudinal stress.

The section was elongated 0.22 in. during each pressure cycle to attain the 22,000 psi longitudinal stress level in the 0.10 in. skin. The bolt holes at the base attachment were slotted so that the elongation was uniform over the 100-inch span of the test section.

The longitudinal stress was induced by applying 350,000 pounds to the floating end plate by means of hydraulic cylinders. The final test consisted of cycling the section from 0 to the maximum design fail-safe stresses until the section ruptured. A 41.29-in. transverse crack through skin and stringers was sustained before rupture occurred.

Baggage-Compartment Door

The test section, representative of fuselage structure in the baggage compartment door area, was subjected to 50,000 pressure cycles from 0 to 8.6 psi. There were no fatigue cracks detected after completion of the test.

A series of fail-safe tests were performed with damage inflicted in various structural components of the baggage door surrounding structure.

It was necessary to apply several hundred cycles from 0-9.3 psi to initiate skin crack propagation in the damaged areas. A crack was started, however, in a corner of the door frame after 1200 cycles when the belt frame tee, skin doubler, and one-inch of skin were cut. The crack extended over the adjacent belt frame after an additional 2000 cycles were applied. Total crack length was 21.37 in.

A test was performed on this section to determine the pressure fluctuation below 9.3 psi necessary to promote an increase in skin crack propagation.

The test simulated cabin pressure variations that might occur due to changes in altitude during flight. Cracks were initiated at the ends of a 6 in. cut in the skin midway between belt frames. The pressure was then fluctuated from 9.3 psi in 0.5 psi increments below 9.3 psi until a change in rate of crack growth occurred as compared to typical 0 to 9.3 pressure cycles.

A fluctuation from 9.3 psi to 6.5 psi was necessary to promote appreciable increase in skin crack growth. This is a much greater pressure variation that would occur during flight.

Canopy and Hydrostatic Tests

Fatigue tests of the 880 pilot's canopy are now in progress. This will be followed by fail-safe tests with induced damage to the windshield posts and adjacent areas.

Finally, to ensure maximum safety of the pressurized cabin, a complete fuselage, including the wing carry through, will be submerged in a hydrostatic tank. Fatigue and fail-safe tests will be performed by cycling the fuselage to cabin operating pressure with water while wing and fuselage bending is induced to simulate the airplane flight, landing, and taxi load cycle.

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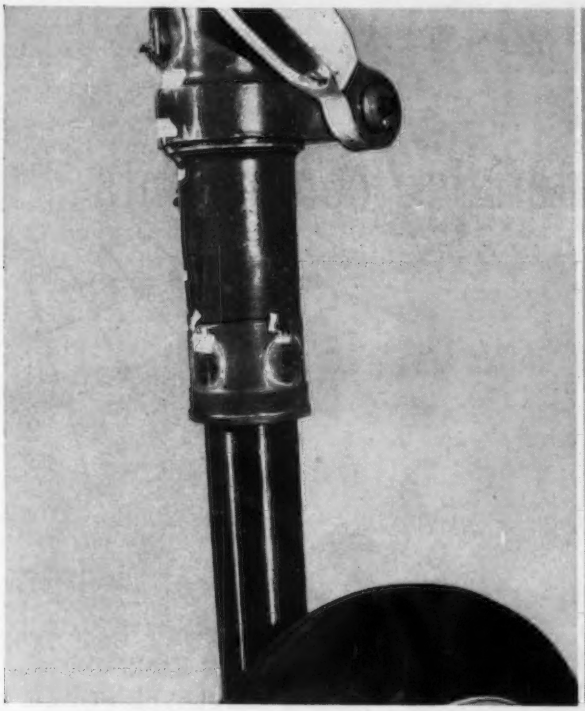

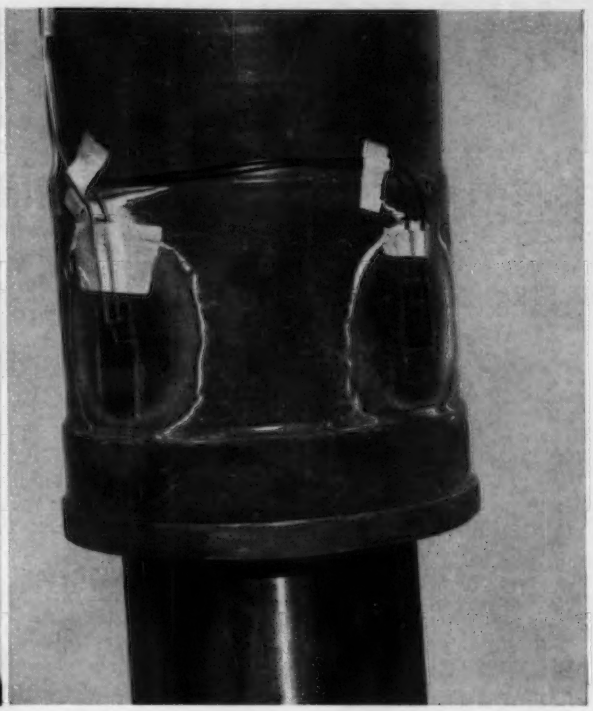

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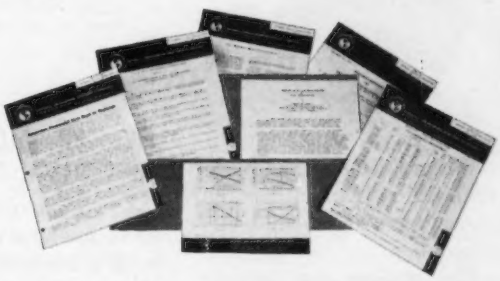
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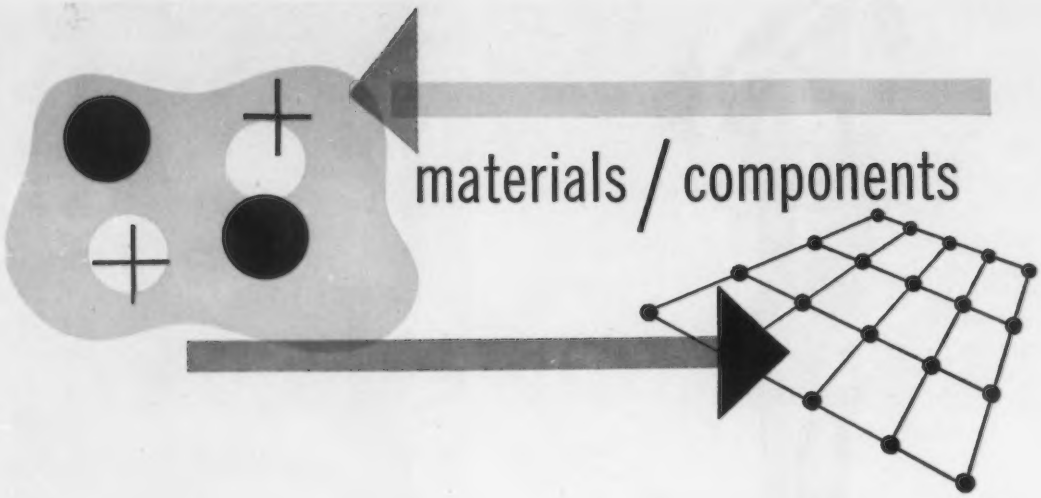
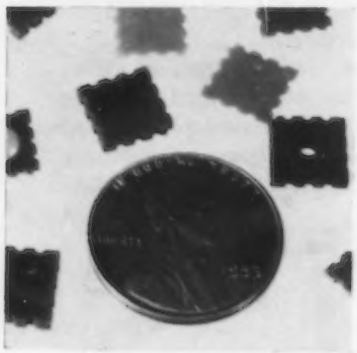


PHOTOETCHED WAFERS CUT CIRCUIT SIZE

Size of circuit assemblies can be reduced with tiny, precision-made "wafers" of Fotoceram. Material is a high-temperature glass-ceramic.



Wafers serve as resistor, transistor, capacitor and diode bases in micro-module circuit assemblies.

The wafers can operate over 500°C. They are formed by photoetching.

Corning Glass Works

Circle 67 on postcard for more data

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Filters have a mechanical indicator to provide differential pressure signal when cleaning is required.

Capable of withstanding 4500 psi, the new mechanical indicator filters can be used for any fluid system.

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Interstate Engineering Corp.

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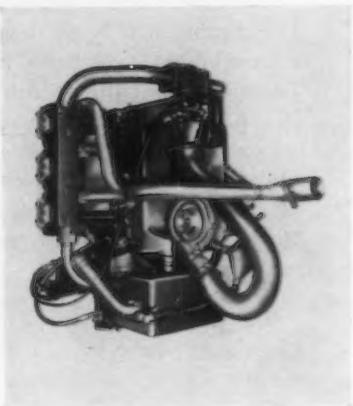

Full weight of the engine, with starter, carburetor, ignition, fuel pump, turbo and complete exhaust system, is only 360 lbs.

Displacement is 335 cu in. with bore and stroke of 4.5 in. x 3.5 in. It is designed to use 100 octane fuel, with fuel consumption of .55 lb./bhp/hr at normal rated power and .50 lb./bhp/hr at 70 per cent power.

Aircooled Motors Inc.

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Westinghouse Electric Corp.

continued on page 55

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TEFLON* NEWS FROM R/M

Now, larger sheets... color-striped thin-wall tubing

Easy identification in multiple tubing installations is made possible by R/M color-striped thin-wall "Teflon" tubing. Tubing is also available without striping.

Larger sheets. R/M now makes 1/32-in.-thick Teflon in 36 x 36 in. sheets. Other "Teflon" products include tape, tubes, rods, hose and bondable "Teflon."

Here are two big features added to Raybestos-Manhattan's extensive line of "Teflon" products for use in aircraft, missile and rocket components. First, 1/32-in.-thick "Teflon" can now be supplied in 36 x 36 in. sheets . . . other thicknesses available in sheets up to 48 x 48 in. And second, to permit the ready identification of lines in multiple installations—R/M thin-wall "Teflon" tubing is now available with a permanent identifying stripe in a range of colors.

These additions reflect R/M's continuing program to extend applications for "Teflon." This program—begun soon after the introduction of "Teflon"—has provided R/M engineers with a vast fund of know-how . . . where to apply "Teflon," how to design with it, and how to fabricate it. Let R/M's "Teflon" know-how work for you. Contact your nearest R/M district office for friendly, competent assistance. Or write for literature to Plastic Products Division, Manheim, Pa.

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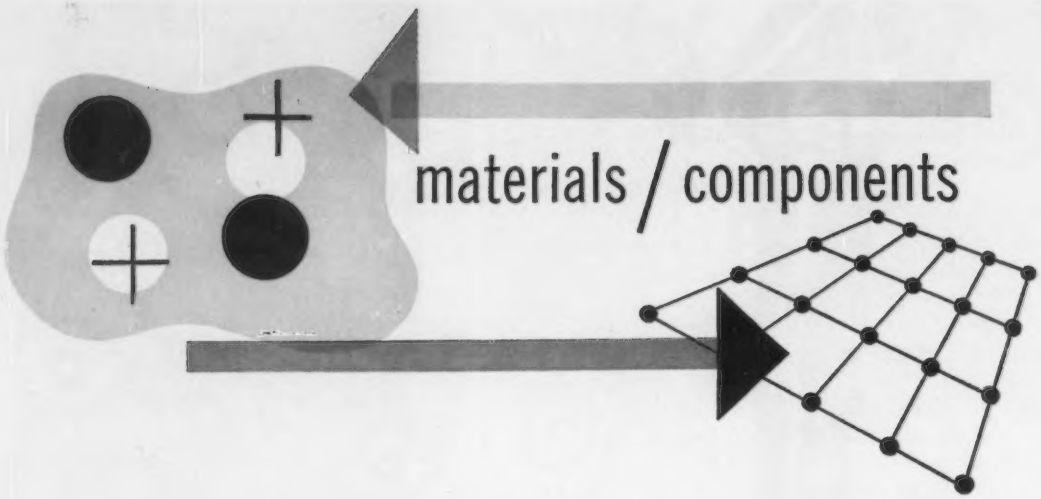

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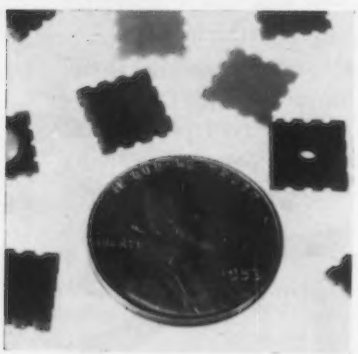

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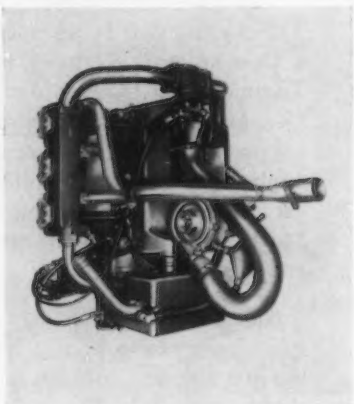

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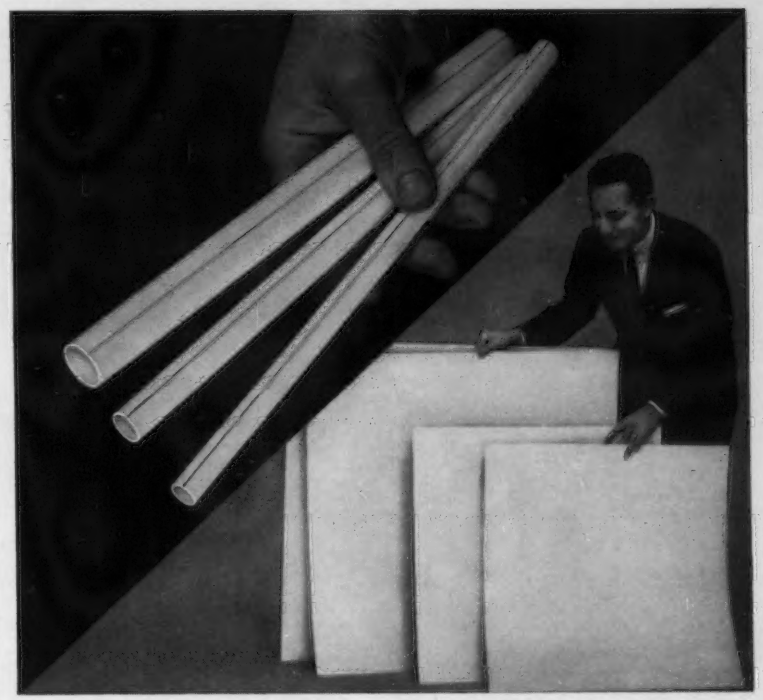


Easy identification in multiple tubing installations is made possible by R/M color-striped thin-wall "Teflon" tubing. Tubing is also available without striping.

Larger sheets. R/M now makes 1/32-in.-thick Teflon in 36 x 36 in. sheets. Other "Teflon" products include tape, tubes, rods, hose and bondable "Teflon."

Here are two big features added to Raybestos-Manhattan's extensive line of "Teflon" products for use in aircraft, missile and rocket components. First, 1/32-in.-thick "Teflon" can now be supplied in 36 x 36 in. sheets . . . other thicknesses available in sheets up to 48 x 48 in. And second, to permit the ready identification of lines in multiple installations—R/M thin-wall "Teflon" tubing is now available with a permanent identifying stripe in a range of colors.

These additions reflect R/M's continuing program to extend applications for "Teflon." This program — begun soon after the introduction of "Teflon"—has provided R/M engineers with a vast fund of know-how . . . where to apply "Teflon," how to design with it, and how to fabricate it. Let R/M's "Teflon" know-how work for you. Contact your nearest R/M district office for friendly, competent assistance. Or write for literature to Plastic Products Division, Manheim, Pa.

*A Du Pont trademark

R/M

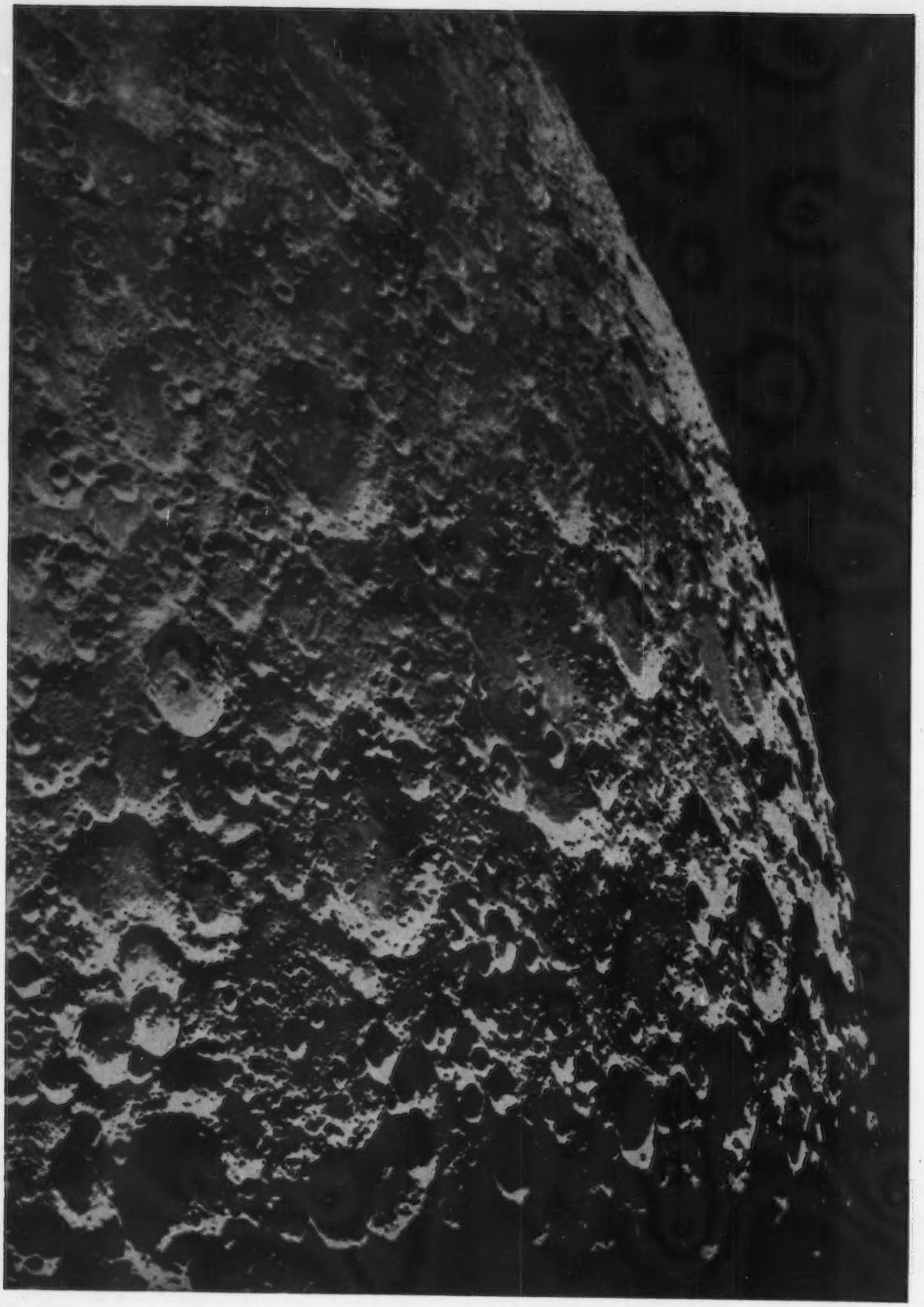
RAYBESTOS-MANHATTAN, INC.

PLASTIC PRODUCTS DIVISION FACTORIES: MANHEIM, PA.; PARAMOUNT, CALIF.

Contact your nearest R/M district office listed below for more information or write to Plastic Products Division, Raybestos-Manhattan, Inc., Manheim, Pa.

BIRMINGHAM 1 • CHICAGO 31 • CLEVELAND 16 • DALLAS 26 • DENVER 16 • DETROIT 2 • HOUSTON 1
LOS ANGELES 58 • MINNEAPOLIS 16 • NEW ORLEANS 17 • PASSAIC • PHILADELPHIA 3
PITTSBURGH 22 • SAN FRANCISCO 5 • SEATTLE 4 • PETERBOROUGH, ONTARIO, CANADA

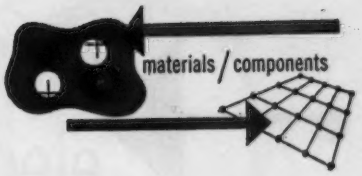
RAYBESTOS-MANHATTAN, INC., Engineered Plastics • Asbestos Textiles • Mechanical Packings • Industrial Rubber
Sintered Metal Products • Rubber Covered Equipment • Abrasive and Diamond Wheels • Brake Linings
Brake Blocks • Clutch Facings • Laundry Pads and Covers • Industrial Adhesives • Bowling Balls



THE
MILITARY
REQUIREMENTS
FOR
MOON BASE

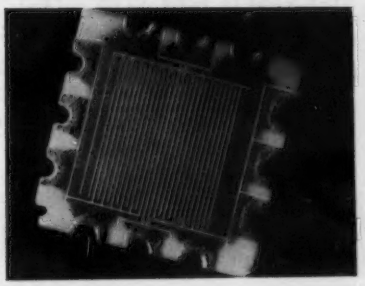
This is the title of one of four major space proposals developed by Martin for the military and astroscientific branches of our Government. The importance of this proposal is two-fold: the inevitability of an actual moon base program by this country within the next 5 years, and; the fact that we could and can undertake such a project now— not in theory but in "hard" engineering design. For Martin's eight divisions add up to one of the top capabilities in the free world for man's first ventures in space-planetary exploration.

MARTIN
BALTIMORE·DENVER·ORLANDO



SMALL RESISTORS WEIGH 50 MILLIGRAMS

Microscopic enlargement of micro-element resistor (actually measuring 0.35 in. square, and ten thousandths of an inch



thick) shows how resistance characteristics are inscribed in the substrates.

Micro-element contains two resistors, but also may be inscribed on the reverse side to make four resistors. Each micro-element resistor weighs 50 milligrams and averages 10,000 elements (or 40,000 resistors) to the pound and a packing density of 600,000 elements/cu ft.

Daystrom-Weston Inst.

Circle 64 on postcard for more data

MINIATURE SPEED CHANGER HAS 25:1 RANGE

A new miniature, adjustable-ratio speed-changer is said to provide increased accuracy, better repeatability and longer life than the manufacturer's earlier model, now widely used in military and laboratory applications.

The Metron, Series 2, has an all aluminum black anodized housing with a longer easy-to-read scale. It is supplied with either servo or foot mounts.

Metron Instrument Co.

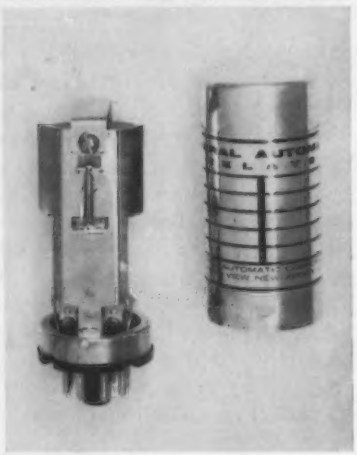
Circle 65 on postcard for more data

electronic products

DUST-PROOF RELAY DESIGNED FOR LOW COST

Small, dust-proof relay has a sensitivity as low as 2 milliwatts per contact in contact combinations from SPST to DPDT.

Round aluminum dust-cover permits easy inspection or adjustment of the relay at any time. Removing the dust cover



exposes adjustment screw on the armature spring.

Relays are designed for low unit cost but a high operating reliability.

General Automatic Corp.

Circle 73 on postcard for more data

METER RELAYS ARE CONTINUOUS READING

New design principle for meter relays retains the reliability of locking contacts, but provides instantaneous reset.

This CR (Continuous Reading) design, allows the moving pointer to show the signal level at all times.

This feature adds an important operating advantage to

locking contact meter-relays. It is expected to extend their application.

Key to the new design is a V-shaped toggle, with contacts on each of its arms. The toggle is pivoted on the under side of the adjustable pointer that marks the set point. Both the toggle and the adjustable pointer are made of layers of isolated metal that are parts of separate circuits from the respective toggle contacts.

Assembly Products Inc.

Circle 74 on postcard for more data

MINIATURE INDUCTORS WEIGH ONLY 0.5 OZ.

Inductance value of miniature toroidal inductors ranges from 1 millihenry to 3 henries.

Useful frequency range is from 10 kilocycles per second to 500 kilocycles per second. Designated Series 783, units measure 1 in. diam. x ½ in. high. Weight is only 0.5 oz.

Built to meet MIL-E-5272A and MIL-T-27A, units are fully encapsulated and hermetically sealed, for maximum resistance to high temperature and extreme shock.

They are available with a 6/32 threaded insert for printed circuit boards, or with a center hole for stacking on a single screw in chassis mounting.

Arnold Magnetics Corp.

Circle 71 on postcard for more data

MEASURES CORROSION

Servo-controlled Model L-2 Corrosometer can detect as little as one millionth of an inch of corrosion on a routine basis and one billionth of an inch in some special applications. It automatically "tracks" corrosion as it occurs, providing a permanent record of the total thickness of metal corroded. This record is presented as a function of time which is quickly converted to the rate of attack.

The pattern of corrosion differs from metal to metal. Model L-2 eliminates the tedious, point-to-point plotting required when the timing and extent of the initial attack is unknown. A single Model L-2 may be used to monitor up to twelve individual tests by adding additional Measuring Units. A single multi-point recorder can be used

to record data from these tests being run in parallel at the same time.

Model measures the ratio of resistances between exposed and protected metal elements mounted on a "probe" that extends into the corrosive medium or sample. As the exposed metal is corroded, the resistance ratio between the two elements increases. This increase is a direct indication of corrosion.

Two metal elements in the probe form two legs of a bridge circuit, with a servo-driven potentiometer acting as the automatic balancing mechanism. The position of this potentiometer is a direct measure of corrosion.

Crest Instrument Div.
Magna Products Inc.

Circle 70 on postcard for more data

DEVICE TO REPAIR PRINTED WIRING

A new induction de-solder and solder device is said to save up to 20 per cent of time in repairing printed wiring assemblies.

Operated manually or automatically, the semi-portable device includes a heat-extract sequence for de-soldering, and a heat cycle for soldering.

The device requires power input of 110 volts, 60 cycles, single-phase 2 kva. It is 30 inches wide, 22 inches deep and 21 inches high. It weighs 250 lb.

General Electric Co.

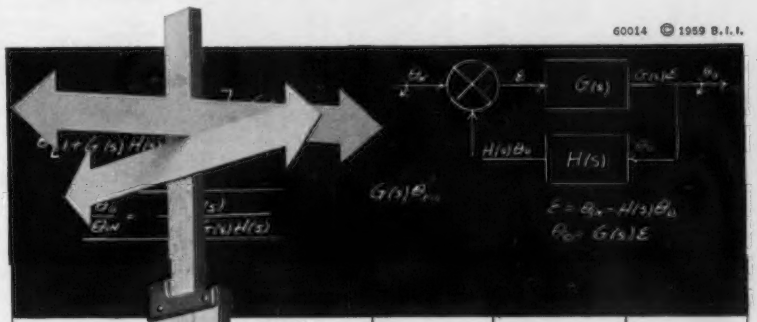
Circle 75 on postcard for more data

continued on next page

sophisticated servo solutions

size 8's that do the work of 10's...15's with 100,000 rad/sec² acceleration...11's and 18's with inertia or adjustable velocity damping. Extract your solution from an infinitude of BECKMAN servomotors.

To satisfy the unknowns in your system, try these representative specs on your slipstick.



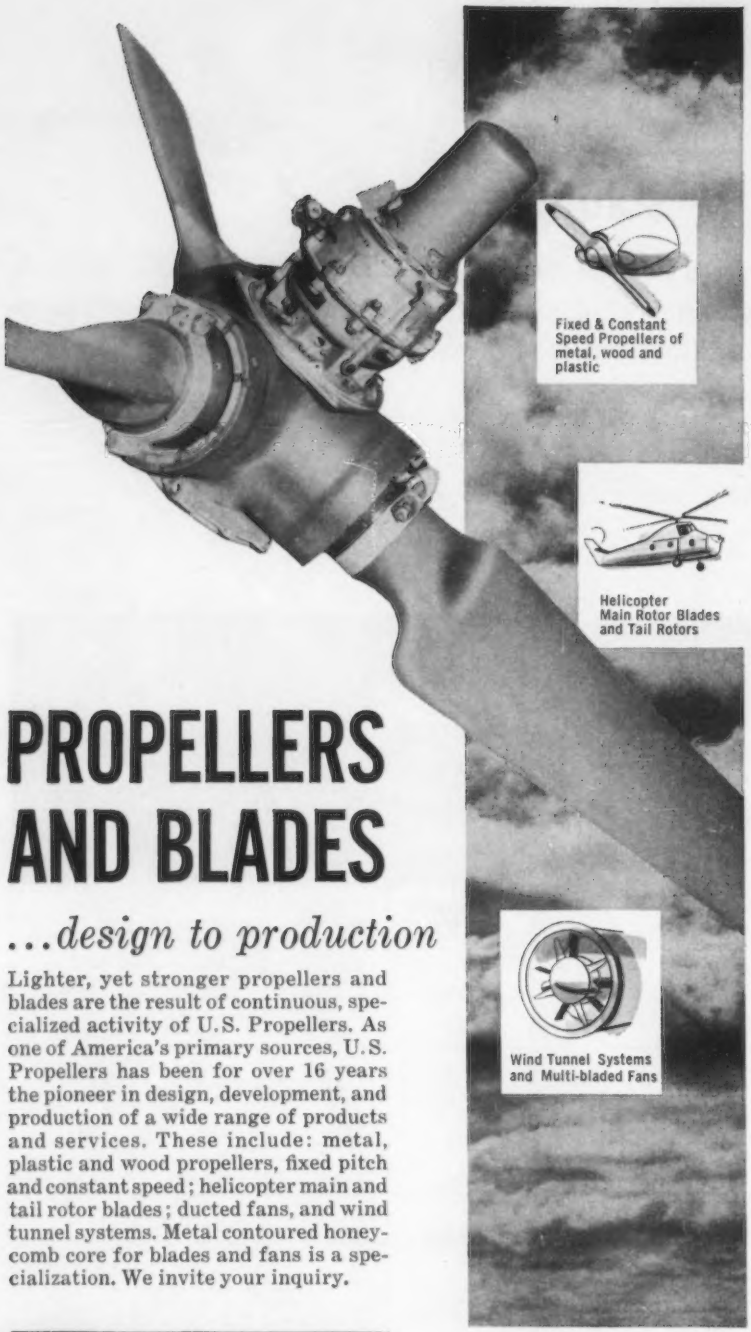
	Size 8 servomotor-rate generator Model 8MG420/410	Size 11 velocity-damp servomotor Model 11VM460	Size 15 servomotor Model 15SM461	Size 18 inertia-damp servomotor Model 18IM460
Excitation	26v 400-cycle	115v 400-cycle	115v 400-cycle	115v 400-cycle
Length, inches	1.350	2.033	1.375	2.525
No-load, rpm	6,000	5,300	6,000	4,700
Torque at stall, oz. in.	0.22	0.63	1.45	2.35
Acceleration at stall, rad/sec²	68,000	22,200	100,000	22,200
Output voltage volts/1,000 rpm	0.1	—	—	—
Null voltage, millivolts	4	—	—	—
Additional damping available dyne cm. sec. / radian	—	10-100 (adjustable)	—	940
	There are 10^{90} standard & spec types available in these popular sizes!			

For complete crib-sheets...specs, drawings, torque speed curves and unit characteristics... write for data file F93.

Beckman® / Helipot®

Helipot Division of Beckman Instruments, Inc.
Fullerton, California
Engineering representatives in 29 cities

potentiometers: dials: delay lines: expanded scale meters: servomotors: breadboard parts


Fixed & Constant Speed Propellers of metal, wood and plastic
Helicopter Main Rotor Blades and Tail Rotors
Wind Tunnel Systems and Multi-bladed Fans

PROPELLERS AND BLADES

...design to production

Lighter, yet stronger propellers and blades are the result of continuous, specialized activity of U.S. Propellers. As one of America's primary sources, U.S. Propellers has been for over 16 years the pioneer in design, development, and production of a wide range of products and services. These include: metal, plastic and wood propellers, fixed pitch and constant speed; helicopter main and tail rotor blades; ducted fans, and wind tunnel systems. Metal contoured honeycomb core for blades and fans is a specialization. We invite your inquiry.

POLY INDUSTRIES

formerly Turbo Products

Write for new U. S. Propellers facilities brochure.

U. S. PROPELLERS, INC.

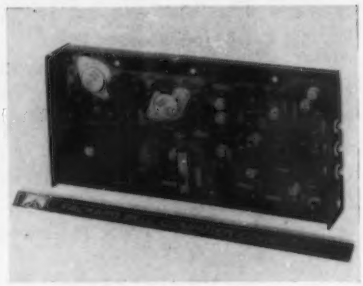
a wholly owned subsidiary

12177 Montague Street • Pacoima, California

electronic products

AMPLIFIERS CLAIM NEW CHOPPER DESIGN

Wide-band, accurate amplification is claimed for the first available line of low-noise, completely solid state amplifiers



with transistor choppers. With this design which eliminates mechanical choppers, amplifier and system reliabilities are increased at least one order of magnitude.

Packard Bell Electronic Corp. Technical Products Div.

Circle 68 on postcard for more data

NEW AUTOMATIC BATTERY TEST AND CHARGER

A new automatic battery tester and charger has been developed for 24 volt aircraft batteries of the lead-acid or nickel cadmium types.

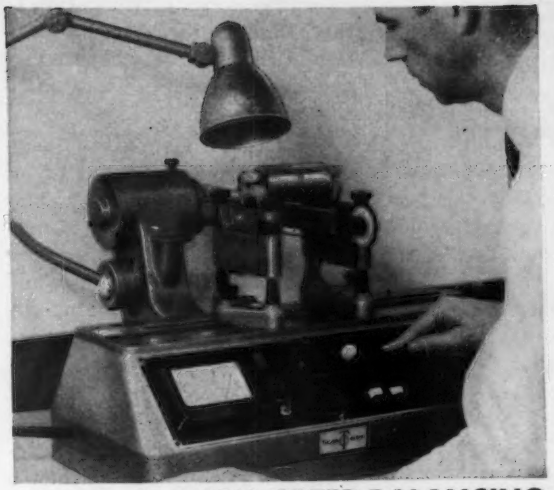
This unit features a unique programmed test-charge

sequence which performs the necessary functions designed to eliminate the possibility of installing defective batteries in aircraft.

Christie Electric Corp.

Circle 69 on postcard for more data

continued on page 60



Now Truly HIGH SPEED BALANCING with the RAVA Type S

Pinpoint and remove unbalance in GYROS, ARMATURES and other rotors more accurately and in less time . . . Production rates up to 80 or more parts per hour . . . Speeds to 12,000 rpm—using peripheral belt drive, air or a magnetic rotating field. Unmatched speed and versatility.

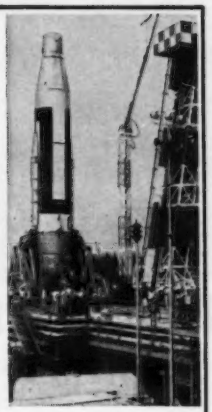
Write for full information.

TINIUS OLSEN
Testing Machine Co.
2210 Easton Rd. • Willow Grove, Pa.

Circle 21 on Inquiry Card

KOHLER PRECISION CONTROLS Specified for GUIDED MISSILES

Superior facilities, experience —plus prompt deliveries— have built confidence in Kohler precision controls for aircraft, automotive and industrial installations. Our engineers develop controls to specifications for volume production. Write for information.



CHECK VALVES:

Connections:
MS-33514 Flareless tube and gasket seal
MS-24385 Flared tube and gasket seal

Operating Pressure:
1500 PSI and 3000 PSI

Proof Pressure:
2250 PSI and 4500 PSI

Burst Pressure:
4500 PSI and 7500 PSI

Temperature Range:
–65° F to 275° F

Material:
1500 PSI Aluminum
3000 PSI Stainless Steel

KOHLER CO. Established 1873 KOHLER, WIS.

KOHLER OF KOHLER

Enameled Iron and Vitreous China Plumbing Fixtures • Brass Fittings
Electric Plants • Air-cooled Engines • Precision Controls

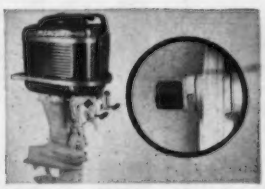
Circle 22 on Inquiry Card

which CaPlug will protect your product best?

write for this free sample kit and see!

WANT TO SEAL OPENINGS IN A JIFFY?
Tapered (non-threaded) CaPlugs can be used as caps or plugs, inside and outside of threaded or plain fixtures. Just push them on . . . or push them in. Costing less to buy, these versatile closures cost less to apply. Time studies show that tapered CaPlugs save up to 500% in labor costs.

WANT TO KEEP FITTINGS UNDER WRAPS?
See how CaPlugs seal out dust and protect fittings of this refrigeration valve during shipment. Says Automatic Machine Products Sales Co., "CaPlugs are easy to install and afford the protection we desire." With ten standard styles stocked in over 500 sizes, CaPlugs are promptly available for nearly every closure need.



WANT TO PROTECT DELICATE THREADS?
Kiekhaefer Corp. guards the threads on the "Ride Guide" steering controls of its Mercury outboard motor with threaded style CaPlugs which the customer can reuse when storing motor. Made of tough, flexible Polyethylene, CaPlugs are kind to threads and polished surfaces — will not collapse, chip, break or shred.

WANT TO ADD SALES APPEAL?
Colorful CaPlugs spruce up your product and reflect the care you have taken to keep delicate systems free of dirt and moisture. This Bristol air control instrument is a good example. Says The Bristol Company, "They are sturdy enough so that they are not accidentally dislodged, but are still easily removable."

MAIL THIS COUPON FOR FREE CAPLUG SAMPLE KIT WITH DESCRIPTIVE LITERATURE AND PRICES

CAPLUGS DIVISION,
PROTECTIVE CLOSURES CO., INC.
2203-3 Elmwood Ave., Buffalo 23, N. Y.

RUSH a free CaPlug sample kit, literature and prices to us, without obligation.

NAME _____ TITLE _____

FIRM _____

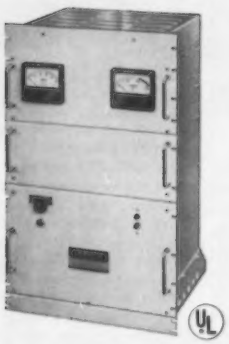
ADDRESS _____

CITY _____ ZONE _____ STATE _____

Circle 23 on Inquiry Card

D-C POWER

Precisely Regulated for Missile Testing and General Use



CHRISTIE

SILICON POWER SUPPLIES

available in 30 standardized and militarized models from 30 to 1500 amps... 6 to 135 volts. CHRISTIE'S QUALITY CONTROL is approved by the A.E.C., leading aircraft and missile manufacturers.

Write For Bulletin AC-58-A

CHRISTIE ELECTRIC CORP.

3410 W. 67th Street
Los Angeles 43, Calif.

Circle 24 on Inquiry Card

electronic products

PUSHBUTTON PLOTTER

A new pushbutton-operated X-Y Plotter incorporates such features as vernier scale ranges, high accuracy and ease of operation.

The X-Y Plotter, Model 210, offers immediate scale switching by pushbutton methods with vernier control permitting scale expansion to the next setting. This permits the operator to expand between scale voltages to fill the entire plot area.

A flat vacuum platen and provision for precision positioning facilitates paper alignment and loading.

A separate switching circuit for X reference and for Y reference permits translation of the X and Y origins to any position in the plot area. Isolated inputs are provided between channels and ground.

Other pushbuttons control power on-off, platen on-off and plot clear. The center scale for 4-quadrant plotting is controlled by pushbutton, as is the X reference, the Y reference and the X-Y reference switching circuits. Continuous trace action also is controlled by pushbuttons as is the plot of symbol plot choice.

The plotter may be installed to operate in either a horizontal or vertical position. Both control panel and plotting table are available for 19-inch rack mounting as well as standard table units.

Librascope Inc.

Circle 72 on postcard for more data

AIRETOOL PNEUMATIC PRODUCTION TOOLS...

...small but mighty

Take Airetool pneumatic drills, for instance. Their high-torque air motors assure fast, clean drilling, yet these tools are compact, lightweight. Easily handled in close quarters. 3/32, 3/16, 1/4, 1/2, 5/8 and 3/4" models. Airetool angle head drills and midget grinders give this same efficient combination of size and power. Another good example is Airetool 500-V sander. Uses 7" flexible disc, weighs just 4 5/8 lbs. Write for Bulletin 67.

BRANCH OFFICES: New York, Chicago, Tulsa, Philadelphia, Houston, Baton Rouge
REPRESENTATIVES in principal cities of U.S.A., Canada, Mexico, South America, England, Europe, Puerto Rico, Italy, Japan, Hawaii
EUROPEAN PLANT: Vlaardingen, The Netherlands
CANADIAN PLANT: Brantford, Ontario

AIRETOOL
MANUFACTURING COMPANY
SPRINGFIELD OHIO
30 years experience in pneumatic tools

Circle 25 on Inquiry Card

Another Operating PLUS for United Air Lines DC-8 Jet Mainliners

The B&H JETCAL® ANALYZER

ASSURES... *maximum range, lower operating costs, greater dependability of schedule operation, better assurance of on-time arrivals at planned destinations!*

TESTS EGT SYSTEM ACCURACY to ±4°C (functionally, without running the engines).
RUNS TEMPERATURE SPREAD CHECK on TWO ENGINES at SAME TIME. CUTS TEST TIME 50%.
TESTS RPM ACCURACY to 10 RPM in 10,000 RPM (±0.1%).
CHECKS HEAT, ANTI-ICE and FIRE DETECTION SYSTEMS.

The JETCAL® is in worldwide use...by the U.S. Air Force and U.S. Navy as well as by major aircraft and engine manufacturers...and air lines. *Write, wire or phone (EDison 6-7243) for complete information.*

B & H INSTRUMENT CO., INC.
3479 West Vickery Blvd., Fort Worth 7, Texas

Sales-Engineering Offices:
ATLANTA, GA., COMPTON, CALIF., DAYTON, OHIO, VALLEY STREAM, L.I., N.Y., WICHITA, KAN., TORONTO, ONT. *(George Kelk Ltd.),* MITCHAM, SURREY, ENGLAND *(Bryans Aeroquipment Ltd., Exclusive licensee and manufacturer for Great Britain, British Commonwealth and Europe)*

Circle 26 on Inquiry Card

NEW PLASMA GENERATOR

A new high temperature source ranging from 2500°F to 12,000°F may have wide application as a low-cost research and production tool.

Powered by a standard welding generator, the unit is basically a high intensity electric arc consisting of a water-cooled tungsten cathode and a copper anode. Part of a family of plasma generators being developed, it can be used in techniques for flame-spraying refractory oxides and ceramics onto other materials to increase their refractory properties.

Avco Research and Advanced Development Div.

Circle 81 on postcard for more data

HIGH ENERGY DENSITY ULTRASONIC CLEANER

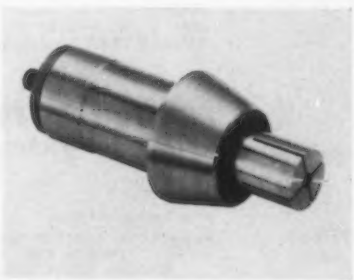
An ultrasonic cleaner has been designed for applications in which high energy density is required. Model 220 "Heavy-dutyline" features a 2-gallon tank made of heavy-gauge polished stainless steel. Tank is 9 in. long, 6 in. wide and 10 in. deep; 44½ per cent of the bottom of this tank is covered with driving elements. Actual radiating surface is 24 sq. in.

National Ultrasonic Corp.

Circle 78 on postcard for more data

EXPANDING COLLET FOR TURRET LATHES

Push-type expanding collet for turret lathes owns a new push-type design. This permits internal chucking of diameters from ¾ in. to six in.



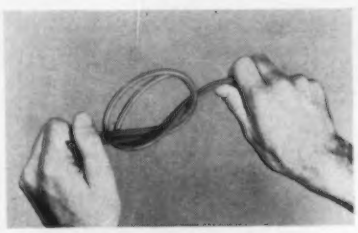
Master collet is 4140 heat treated steel. Types 1 through 5 W & S are available.

Soft expanding mandrels are stocked in 1 in., 1½ in., 2 in. and 2½ in. diameters. They are 1½ in. or 2 in. long.

Accurate concentricity is assured by easy machining to required size or shape on lathe.

The Dunham Tool Co.

Circle 77 on postcard for more data



CUTS TWO-THIRDS OFF HOSE WEIGHT

A new air hose will neither "balloon" in hot weather nor stiffen in cold weather. It weighs about one-third as much as rubber hose.

The hose is designed for use with portable air-operated tools. It is light and flexible.

Made of a special polyamide formulation, the air hose

possesses nylon's inherent imperviousness to oils, its dimensional and chemical stability and toughness.

The microfinished bore is held to tolerances of ±.005 inch. This permits maximum air flow unobstructed by imperfections found in most rubber air hose.

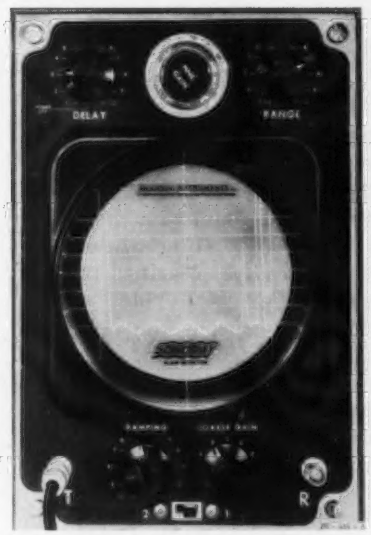
Hose is supplied in 3/16, ¼, 5/16 and ⅜ inch ID sizes, each in 500-foot lengths heat-sealed in polyethylene bags.

Synflex Products Div.
Samuel Moore & Co.

Circle 80 on postcard for more data

DETECTS FLAWS ULTRASONICALLY

Ultrasonic test instrument offers reduced weight and volume for uses in field inspection as well as contact and immersion work.



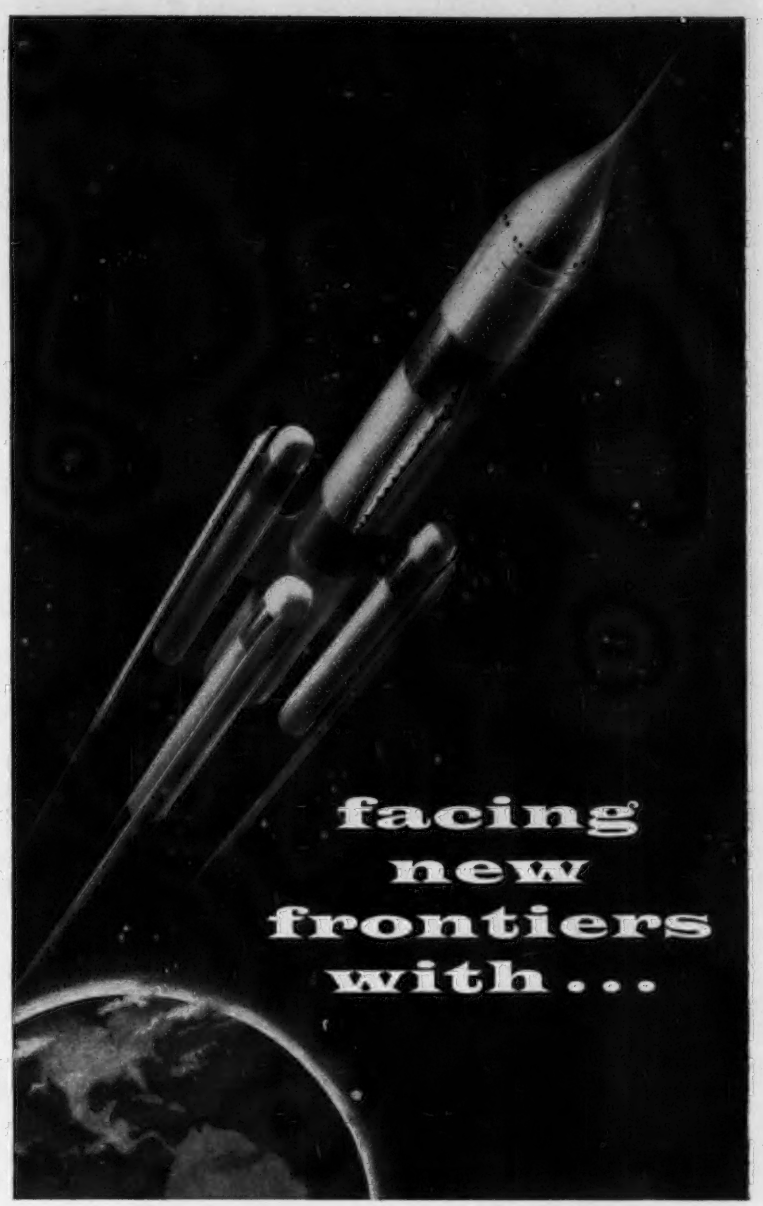
Ultrasonic pulses are sent into the material under test and, together with the returning "echo," are displayed on a cathode ray tube. Variations in the normal pattern indicate a flaw or discontinuity.

A broad-band amplifier permits a continuous range of test frequencies. Instrument will automatically adjust to any transducer within its operating range of 0.4 to 10 mc.

Branson Instruments Inc.

Circle 82 on postcard for more data

continued on next page



BERYLLIUM

There are many good reasons why beryllium is increasingly used by aircraft and missile-makers.

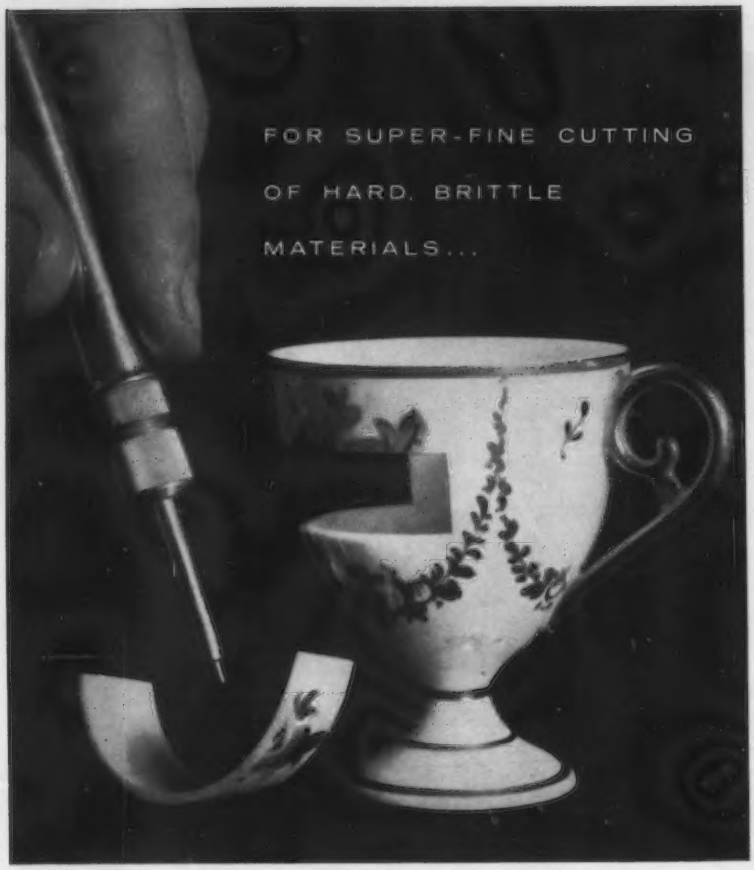
- light weight
- high modulus
- high temperature strength
- excellent thermal conductivity

Today, beryllium parts are being designed by missile and aircraft manufacturers into *current* programs. This is one of the metal's growing new frontier areas.

A free illustrated brochure on Berylco HPA beryllium is available. Write to—

BERYLCO® **THE BERYLLIUM CORPORATION**

P. O. Box 1462, Reading, Pennsylvania



THE S. S. White® Industrial Airbrasive® Unit

We don't recommend slicing up the family's fine Limoge China, but this does illustrate the precisely controlled cutting action of the S. S. White Airbrasive Unit. Note how clean the edge is, and how the delicate ceramic decoration is unharmed.

The secret of the Airbrasive is an accurate stream of non-toxic abrasive, gas-propelled through a small, easy-to-use nozzle. The result is a completely *cool* and *shockless* cutting or abrading of even the most fragile hard materials.

Airbrasive has amazing flexibility of operation in the lab or on an automated production line. Use the same tool to frost a large area *or* to make a cut as fine as .008"!...printed circuits...shaping and drilling of germanium and other crystals...deburring fine needles...cleaning off oxide coatings...wire-stripping potentiometers...engraving glass, minerals, ceramics. Jobs that were previously thought impossible are now being done.

Send us samples and specs on your difficult jobs and let us test them for you.

SEND FOR BULLETIN 5705A... complete information.

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S. S. WHITE INDUSTRIAL DIVISION
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Exclusive representatives for Arizona and California
WEIGHTMAN AND ASSOCIATES, Burbank, Calif

VAPOR DEGREASER USED IN ULTRASONIC CLEANING

Bench-size single-stage vapor degreaser, SonBlaster Model D-601, is designed to insure that after a part has been cleaned ultrasonically it has no residual contaminated solvent. This is accomplished by suspending the part in condensing vapors of pure distilled solvent. It has a one-gallon capacity.

Narda Ultrasonics Corp.

Circle 76 on postcard for more data

CENTERLESS GRINDING

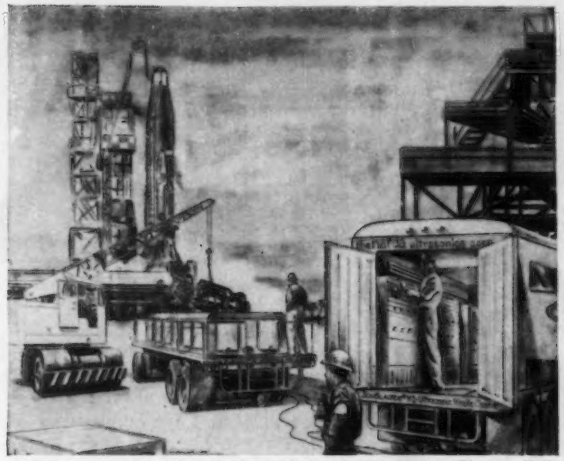
Straddle-Bearing Centerless Grinder was recently unveiled. One of the features which contributes to the overall ruggedness is the introduction of Straddle Bearings on the grinding and regulating wheel spindles. Straddle Bearings provide support on both sides of the wheel to prevent the deflection normally encountered when an extra wide wheel is mounted on the end of a spindle which is unsupported. This extra support counteracts, too, the tendency for the spindle to deflect under heavy grinding pressure. The outboard bearing is rigidly fixed in the combination spindle bearing support bracket and heavy wheel guard cover.

The Norton Centerless Grinder employs a grinding wheel slide with rotating feed screw for precise wheel feed on plunge grinding operations or fine adjustment for sizing on thru-feed grinding.

Wheel feeding or adjustment is made by a handwheel with a click-count wheel feed.

Norton Co.

Circle 79 on postcard for more data



Artist's conception of the Narda SonBlaster® M1 Missile Cleaner. Fully mobile and self-propelled, the new ground support equipment is designed for use at launching pads and missile assembly plants.

Ultrasonic Missile Cleaner Announced by Narda

Westbury, L. I. (N.U.)—Introduction of the M1 Ultrasonic Missile Cleaner has been announced by the Narda Ultrasonics Corporation. Designed to be fully mobile and self-contained, the complete equipment includes an air-conditioned van containing all necessary electronic gear and a flat bed trailer in which missiles, jet engines and other large assemblies may be cleaned.

The flat bed trailer is 24 feet long and supports a transducerized tank measuring 20′ long by 6′ wide by 3′ deep, towed by a cab-over-engine type power tractor. Thirty kilowatts input are required by the transducers, paired in 1 kw modules for easy field maintenance and replacement.

Power is supplied to the transducers by 12 Narda SonBlaster G-25001 generators, installed in the rear of the van. All necessary cables and maintenance facilities are included in the van.

This new GSE concept of ultrasonic cleaning has been pioneered by Narda, producers of more ultrasonic cleaners than all other companies put together. It is the latest addition to the SonBlaster line of cleaning and degreasing equipment ranging from 35 watts to 2.5 kw generating power, including transducerized tanks and immersible transducers. More information about the M1 Missile Cleaner, fuel pipe line cleaners, and other SonBlaster ultrasonic cleaners can be obtained by writing Narda at Dept. AMM-9.

the narda ultrasonics corporation

625 MAIN STREET, WESTBURY, L. I., N. Y. • EDgewood 3-5400
5785 North Lincoln Ave., Chicago, Illinois • LOng Beach 1-4625
3259 Wilshire Boulevard, Los Angeles 5, Calif. • DUnkirk 8-2201
Subsidiary of The Narda Microwave Corporation

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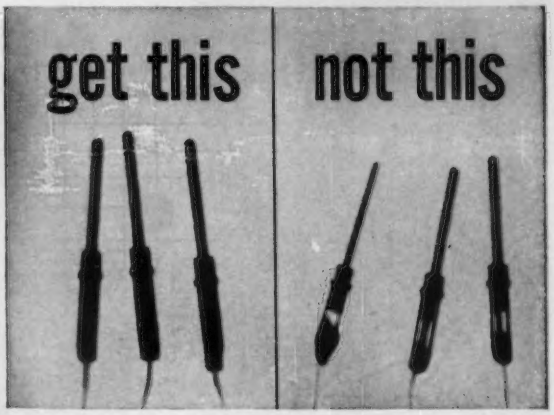


Actual X-ray Photos Show How IDEAL Thermo-Tip Resistance Soldering Tools Reduce Costly Voids in Winchester and Cannon Plug Pins

Because the whole pin is heated, "cold-flow joints" are eliminated; failures are greatly reduced

Pin No.	Conduction Method: Length of void	Conduction Method: % of void	Resistance Method: Length of void	Resistance Method: % of void
1	0.12″	40	0.00″	0
2	0.12″	40	0.00″	0
3	0.07″	23	0.05″	17
4	0.18″	60	0.00″	0
5	0.06″	20	0.06″	20
6	0.05″	17	0.04″	13
7	0.02″	7	0.05″	17
8	0.08″	27	0.01″	3
9	0.09″	30	0.07″	23
10	0.12″	40	0.09″	30
11	0.15″	50	0.04″	13
12	0.12″	40	0.06″	20
13	0.09″	30	0.01″	3
14	0.12″	40	0.08″	27
15	0.11″	37	0.02″	7
16	0.10″	33	0.04″	13
17	0.07″	23	0.04″	13
18	0.09″	30	0.09″	30
19	0.11″	37	0.10″	33
20	0.11″	37	0.06″	20
21	0.05″	17	0.01″	3
22	0.15″	50	0.00″	0
23	0.11″	37	0.05″	17
24			0.07″	23

● These production test results from a major Aircraft manufacturer prove the superiority of Ideal Resistance Soldering Tools to the best available commercial soldering irons. Voids averaged 33% with soldering irons. With resistance soldering only 14%.

In addition, higher production speeds were possible on Cannon plugs and operators were less subject to painful burns. Send for descriptive literature.

IDEAL INDUSTRIES, Inc., 1390-I Park Ave., Sycamore, Ill.

Gentlemen: Please send complete catalog information about Ideal's Thermo-Tip Resistance Soldering Tools.

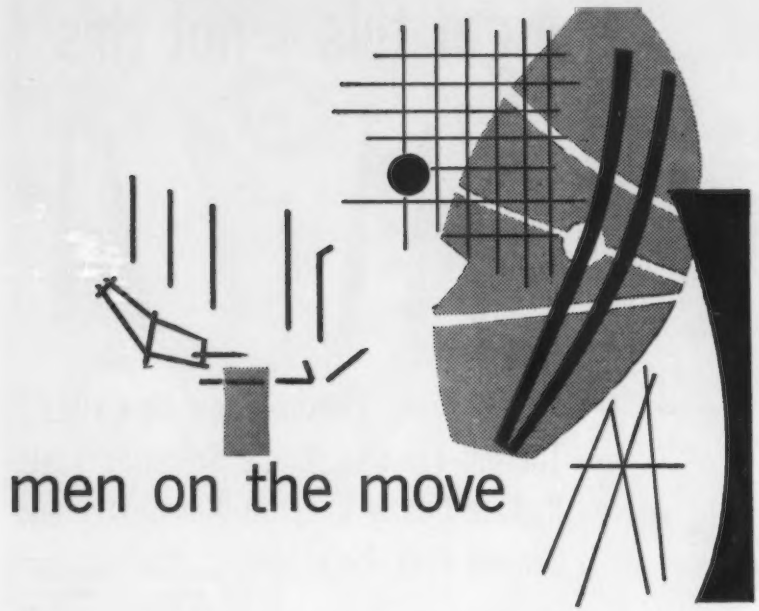
Name_____

Company_____

Address_____

City_____ Zone____ State_____

Circle 30 on Inquiry Card



men on the move

JOHN H. RICHARDSON, named director of marketing; CLARENCE A. SHOOP, named manager of the International Div.; DAVID A. HILL, appointed manager of the Santa Barbara, Calif., research center; JOHN L. WINKEL, appointed manager of the Washington, D. C., office; at Hughes Aircraft Co.

CARL WOOTTEN, appointed vice-president of L. B. Smith Aircraft Corp.

DR. ANGELO MIELE has joined the Boeing Scientific Research Laboratories. He will direct research in astrodynamics and flight mechanics.

VINCENT GLEASON, appointed to the new position of operations manager of the Paraglas Div., Air Logistics Corp.

Gerret B. Conover
Propulsion Test Facilities

Joseph F. Hill
Janitrol

GERRET B. CONOVER, appointed assistant chief engineer, Propulsion Test Facilities, Inc.

JOSEPH F. HILL, appointed Manager of Engineering, Janitrol Aircraft Div., Surface Combustion Corp.

THOMAS A. JOHNSTON, named chief of a new space power systems group in the Research and Engineering Requirements Dept., Tapco Group, Thompson Ramo Wooldridge Inc. JOHN B. CROBAUGH, named manager of the Powers Systems Works. WILLIAM P. BENTE succeeds Crobaugh as manager of the Fuel Systems Works.

WILLIAM R. BUTLER, appointed manager of castings sales at Aluminum Co. of America.

ROY J. SANDSTROM has joined Bendix Aviation Corp. as assistant general manager of the Bendix Systems Div. ELDRED E. EVANS, named general manager; and ROBERT J. QUIRK, named asst. general manager of the Kansas City Div.

FREDERICK A. FIELDER, elected vice president and general manager of the Loewy-Hydropress Div., Baldwin-Lima-Hamilton Corp.

J. E. DATA, appointed sales manager, electric welding, Linde Co.

DR. DONAL B. DUNCAN has joined Aeronutronic, div. of Ford Motor Co., as asst. operations manager of Space Technology Operations.

W. L. WHITTIER has been named factory superintendent at the El Segundo Div., Douglas Aircraft Co. W. E. LUFF, chief, quality control, succeeds Whittier as division manager of product reliability.

JAMES F. COLEMAN, appointed vice president, marketing at Bill Jack Scientific Instrument Co., Solana Beach, Calif.

J. R. Clark
Chance Vought

David A. Young
Aerojet-General

J. R. CLARK, named general manager of the new Astronautics Div. in Chance Vought Aircraft's realignment into five divisions. W. PAUL THAYER becomes general manager of the Aeronautics Div. RAYMOND C. BLAYLOCK has overall supervision of both the Astronautics and Range Systems divisions.

DAVID A. YOUNG, appointed director of corporate long range planning at Aerojet General Corp. DR. MARVIN H. GOLD, appointed associate director of chemistry at Aerojet's Chemical Div., Sacramento, Calif. V. R. BOULTON, named asst. manager of the Test Div. of the Sacramento plants. RUDI BEICHEL, named project engineer for redesigning Titan first stage engines to second stage use on the Saturn space vehicle.

MILTON FARBER, appointed vice president of basic research at Rocket Power, Inc.

Carl L. Sadler
Sundstrand Corp.

William C. Benson
Solar

CARL L. SADLER, promoted to Vice-President in charge of Aviation and Defense Products Group, Sundstrand Machine Tool Co.; P. A. ANDERSON, now Director of Aviation and Defense Product Sales; DONALD L. CAUBLE, Manager, Sundstrand Aviation; and E. W. KRUGER, now Chief Engineer, Sundstrand Aviation.

WILLIAM C. BENSON, named project engineer, ground support equipment, for Solar Aircraft Co.

WALTER JOHNSON, appointed manager of the facility services department at the Georgia Nuclear Laboratories, Lockheed Aircraft Corp.

H. WYMAN HOWARD, appointed manager of military requirements of Sylvania Electronic Systems.

C. EARNEST SILK, named director of development for the solid propellants and explosives operations of the Energy Div., Olin Mathieson Chemical Corp.

HUBERT BENNETT, named director, applications engineering, for McCormick Selph Associates.

TED R. THOREN, appointed vice president of engineering, Pesco Products Div., Borg-Warner Corp.

FRANK L. BAILEY, named president and sales manager of Chemical Milling International Corp. E. LAWRENCE BREVIK, now vice president and technical director.

ROBERT L. EGBERT, appointed assistant to the sales manager of Dixon Sintaloy Inc.

GERALD E. CAMPBELL, appointed vice president of manufacturing, United Aircraft Products Inc.

FRED RAUSCHENBACH has joined United ElectroDynamics Inc. as manager of development planning.

HENRY P. STEIER, appointed director of public relations for Lear Inc.

ROLLAND BOARDMAN, named manager of purchases for Piper Aircraft Corp.

GEORGE M. ROUZEE, promoted to sales manager for the Western Development laboratories, Government and Industrial Div., Philco Corp.

ALAN E. ALGRE joins Meletron Corp. as process engineer in manufacturing.

WILLIAM F. NEWBOLD, appointed director of research for the Brown Instruments Div. of Minneapolis-Honeywell Regulator Co.

ANDREW C. BAYLE, elected vice president, engineering, Waltham Precision Instrument Co.

HEINZ HANAU, named director of engineering and research at Industrial Tectonics Inc., Western Div.

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TEMPERATURE ALTITUDE HUMIDITY CHAMBER

- Temperature Range −120°F to+500°F
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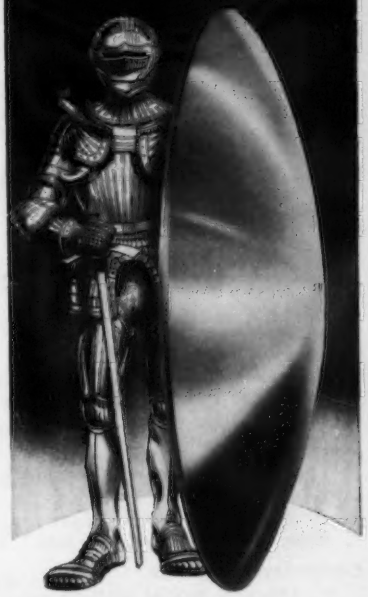
SHIELD FOR THE BATTLE OF SURVIVAL IN SPACE



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Circle 32 on Inquiry Card

worth asking for:

technical literature listed here is available without charge from the various manufacturers

V.I.P.

Brochure presents complete description of Visual Integrated Presentation which integrates instrumentation data into a single display for pilot.

Chicago Aerial Industries

Circle 122 on postcard for more data

Elgiloy

26 page handbook gives full data on Elgiloy "wonder" alloy.

Abrasives Div.
Elgin National Watch Co.

Circle 95 on postcard for more data

SDC

Facilities brochure gives firm's setup, work.

System Development Corp.

Circle 114 on postcard for more data

Rol-a-Chart

Description of chart which moves with time as reminder.

Conley, Balzer & Steward

Circle 89 on postcard for more data

Silcad Batteries

Technical brochure on long-life silver-cadmium cells.

Yardney Electric Corp.

Circle 84 on postcard for more data

Lear

Booklet on organization, products, facilities.

Lear Inc.

Circle 103 on postcard for more data

Electromagnetic Relays

134 page booklet contains complete papers of seventh annual conference on electromagnetic relays.

Potter & Brumfield
Div. of American Machine & Foundry Co.

Circle 111 on postcard for more data

Sealed Relays

Diagrams and specifications on hermetically sealed microminiature and high speed relays.

General Electric Co.

Circle 112 on postcard for more data

Press Brakes

Full information on Series IB press brakes, 15, 30 and 60 ton machines.

Niagara Machine & Tool Works

Circle 85 on postcard for more data

Epoxy Resin Diluent

Technical information sheet 71 on reaction of octylene oxide with epoxy curing agents.

Chemicals and Plastics Div.
Food Machinery and Chemical Corp.

Circle 93 on postcard for more data

Shape-Cutting Machine

Bulletin on Oxwell CM-60 flame cutting machine automatically reproducing intricate metal parts using oxy-acetylene cutting torches.

Linde Co.
Div. of Union Carbide Corp.

Circle 113 on postcard for more data

High Temperatures

Dimensions, construction, description of line of ovens, incubators and special purpose cabinets.

Arthur S. LaPine and Co.

Circle 99 on postcard for more data

Ways and Gibs

Catalog of latest sizes ways and gibs.

The Ohio Knife Co.

Circle 123 on postcard for more data

Jig Borers

Design, specifications of End Measure Jig Borers.

Pratt & Whitney Co.

Circle 102 on postcard for more data

Ampex

Booklet on facilities, organization.

Ampex Instrumentation Div.

Circle 83 on postcard for more data

Breadboard Parts

Description of all parts for electromechanical breadboard parts.

Helipot Corp.
Div. of Beckman Instruments Inc.

Circle 86 on postcard for more data

CO_2

Report, "Who's Who in CO_2" presents new techniques for CO_2-shielded welding processes.

A. O. Smith Engineering Service Corp.

Circle 91 on postcard for more data

Metals—Platinum

General brochure, "Platinum-Group Metals."

Metals & Controls Div.
Texas Instruments Inc.

Circle 104 on postcard for more data

T55

Description of T55 turboprop engine with breakdown of functions of main parts.

Lycoming
Div. of Avco. Corp.

Circle 120 on postcard for more data

T53

Description of T53 gas turbine with breakdown of functions.

Lycoming
Div. of Avco Corp.

Circle 121 on postcard for more data

Curtiss-Wright

Outline of r & d facilities, manufacturing equipment.

Santa Barbara Div.
Curtiss-Wright Corp.

Circle 92 on postcard for more data

Gyro Compass

Description of subminiature gyro compass unit weighing under 35 lb.

American Bosch Arma Corp.

Circle 97 on postcard for more data

Relays

Catalog on line of relays, sensitrols, solenoids.

Universal Relay Corp.

Circle 110 on postcard for more data

IGW

Brochure lists all of firm's production equipment.

Indiana Gear Works Inc.

Circle 100 on postcard for more data

Synchronous Motor

Brochure describes "Slo-syn" synchronous motors.

The Superior Electric Co.

Circle 106 on postcard for more data

Structural Testing

Brochure pictures, describes complete structural test facilities.

Missile and Space Vehicle Dept.
The General Electric Co.

Circle 117 on postcard for more data

Flexible Hose

Bulletin on double convoluted metal hose for minimum flexibility loss in high temperature and high pressure applications.

Breeze Corporations Inc.

Circle 98 on postcard for more data

Nickel-Containing Castings

Condensed data on major nickel-containing casting alloys.

The International Nickel Co.

Circle 87 on postcard for more data

Hydraulic Pumps

Drawings, features of line.

Hydraulic Products Div.
Clark Equipment Co.

Circle 108 on postcard for more data

Noise

Booklet, "An Introduction to Noise Control."

Industrial Acoustics Co.

Circle 107 on postcard for more data

Ultrasonic Cleaning

Booklet, "Tips on Ultrasonic Cleaning."

Circo Ultrasonic Corp.

Circle 90 on postcard for more data

Floodlights

184-page bulletin 2714 covers, designs, uses, specifications of floodlights.

Crouse-Hinds Co.

Circle 96 on postcard for more data

International Inch

Conversion chart and booklet "The New International Inch . . . And How It Will Affect Your Operations."

Pratt & Whitney Co. Inc.

Circle 101 on postcard for more data

Cartridge Turbostarter

Technical report on AS-26 cartridge turbostarter for aircraft engines includes design approach.

General Electric Co.

Circle 119 on postcard for more data

Radioactivity Monitoring

Bulletin M-59 describes monitoring systems for radioactivity.

Nuclear Measurements Corp.

Circle 105 on postcard for more data

Dimensionair

Catalog 59D gives specs, features of advanced air gage system.

Federal Products Corp.

Circle 94 on postcard for more data

Shock Tester

Features, technical details on tester for production application.

Rochester Div.
Consolidated Electrodynamics Corp.

Circle 115 on postcard for more data

Conversion Charts

Conversion charts for altitude pressure and temperature from —5000 ft to 1,800,000 ft.

Conrad Inc.

Circle 88 on postcard for more data

Tape Recorder

Brochure on new miniaturized AR-200 Airborne Magnetic Tape Recorder.

Instrumentation Div.
Ampex Corp.

Circle 116 on postcard for more data

Aircraft Tubing

Updated Technical Handbook A-2 describes seamless aircraft tubing, carbon, and alloy steels.

Ohio Seamless Tubing Div.
Copperweld Steel Co.

Circle 118 on postcard for more data

Speed Reducers

Bulletin No. 97 describes new Series 8 & 9 miniature fixed ratio speed reducers.

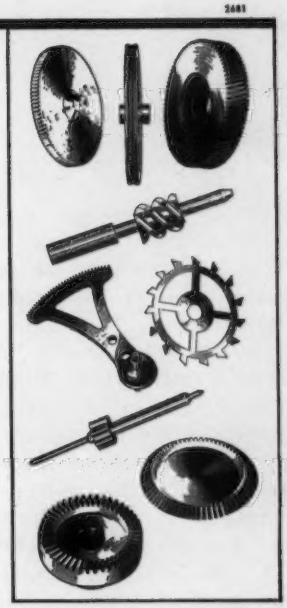
Metron Instrument Co.

Circle 109 on postcard for more data

-GEARS

. . . to critical tolerances

2681



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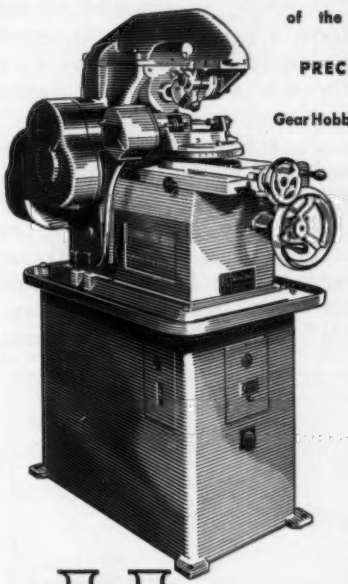

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industry notes

ADVANCES TOWARDS SKY PLATFORMS

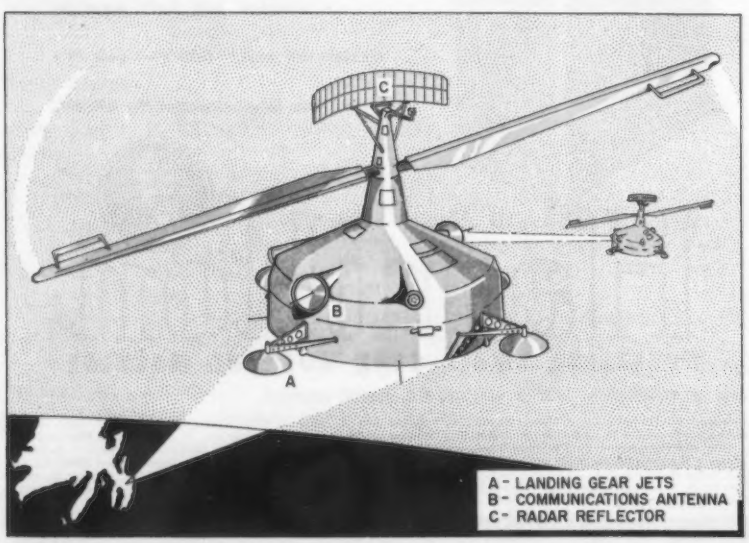
by Peter Sigmund

Planned operation of Raytheon's proposed sky stations:

▸ A battery of Amplitrons (microwave amplifying tubes) generates microwave power. A 400-foot-square array of antennas beams these high frequency radio waves to a series of concave reflectors on the bottom of the platform.

▸ Reflectors function as receiving antennas, conducting the microwave energy through waveguides to "lossy" elements. The energy is absorbed in the form of heat. This is converted to tip-jet propulsive power through a gas-turbine engine and compressor.

▸ Each platform is planned as 80 to 100 ft. in diameter. For use as an early warning line, a rotating antenna on the station directs pulses transmitted from the ground. For Europe-U. S. television relaying, communications antenna are located on the sides of the platform. Lightweight chemical powerplant supplies auxiliary energy. With low disc loading, the platform descends largely by autorotation, with the supplementary power available for precision maneuvering near the ground. Its ascent also utilizes the chemical powerplant.



A $90,000 Air Force contract for a six months' study of converting microwave energy into heat energy was recently awarded Raytheon. Successful application means wireless transmission of power would be achieved.

Studies keep trim to less than one degree by tilting the rotor, relative to the fuselage and antennas. Fuselage tilting is avoided by locating rotor hub near the center of gravity. Fuselage-mounted pressure jets are also utilized for control.

Though a height of several miles might be sufficient for television relay purposes, there is reason to believe Raytheon plans to bring its platforms to heights far exceeding

any reached by rotary-winged craft.

On the basis of its studies and consultants, Raytheon calls the sky platform project "technically feasible." The breakthrough making it possible: a new method of cooling the Amplitrons so that the tube can be designed to handle, according to Raytheon, "many kilowatts of power."

"500-horsepower tubes are confidently expected to be available after a three-year development period," the firm adds.

Further microwave implication for anti-missile defense is highlighted by an Air Force contract to Varo Manufacturing Co. to study uses of microwave radiation to neutralize or detonate a missile's nuclear warhead.

Hopes for a television relay chain envisage four stations about 700 miles apart. The platforms could be located above ground stations on Newfoundland, Greenland, Iceland, and Scotland.

Vehicle, still within the atmosphere, moves with the earth's rotation, thus remaining effectively stationary in relation to a fixed point. Probably manned in test flights, it would operate automatically in its ultimate use, and descend at intervals of several weeks for servicing.

Shaft power taken off the engine drives compressors which force atmospheric air through a rotor-blade duct system and ejects it from the wingtip pressure jets.

Approximate overall efficiency (generated power to rotor power) is 9.6 per cent. Total required microwave power for 1000 rotor hp is then about 10,000 hp.

One estimate on time needed to develop the proposal: five years. Because of its previous experience, Raytheon

continued on next page

Insulator for a scimitar antenna

NEW FLUOROCARBONS

...high production; custom development

Lefco Products is one of America's leading sources of fluorocarbons and other specialized plastics — from research and development to volume production. Lefco fluorocarbon plastics have a unique combination of properties over wide temperature range (−450°F. to +500°F.) providing broad application in aircraft, missiles, electronics and industry. High thermal stability, excellent dielectric qualities, chemical inertness, zero water absorption, self-lubricating and low friction, make these Lefco products ideal for use as insulators, seals or low friction components. We invite your inquiry today.

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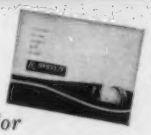

Write for Lefco literature.

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12177 Montague Street • Pacoima, California

Aeroquip Ratchet Buckle and Webbing Eliminates Expensive Jigs and Fixtures

—SAVES TIME DURING FABRICATION OF SHEET METAL

CURTISS-WRIGHT WELDS ROCKET MOTOR CASES POSITIONED WITH AEROQUIP STRAPS

Accurate positioning of these large steel sheets are assured by the infinitely adjustable ratchet buckle. The high-strength strap and buckle assembly has a rated strength of 5000 lbs.

Aeroquip Web Straps with Ratchet Buckles are used to simplify production of rocket motor cases at Curtiss-Wright Corporation's Wright Aeronautical Division. Rolled steel is held by the straps in cylindrical form for welding, as pictured. The ratchet buckle operates as a miniature winch, tensions to 500 pounds, offers infinite adjustment, easy tensioning and quick, safe release of the web strap.

Aeroquip manufactures a wide range of straps and buckles and high strength chain and cable tie-downs.

If you have a materials handling problem involving tie-down or positioning of large structural materials, let Aeroquip engineers save you time and money. Mail the coupon below for details.

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- ☐ Truck Cargo Control Systems

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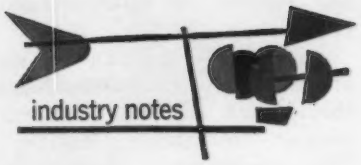


would probably work on heat absorption and all aspects of power, radar and communication. Work on the closely-allied heat exchanger, and the chemical powerplant, airframe and helicopter rotors would be subcontracted.

Though it may initially cause technical frowns, Raytheon's proposal offers at least imagination and probably a a good deal more. Other uses might include long range telegraph communications, weather detection, "lighthouses in the sky." Under the latter concept, microwaves would be converted to colored light by gases in the platforms.

SATURN SADDLED

Project Saturn's three-stage 580-ton vehicle is planned as sort of a space workhorse, according to ARPA director Roy Johnson.

Saturn could reportedly carry a ton of instruments to a soft landing on the moon. It could also thrust a communications satellite 22,000 miles above the earth. The satellite would orbit the earth once every 24 hours, thus remaining stationary in regard to a fixed point along the equator.

Target date for orbiting: 1962-63.

HANDY FACTS . . .

Copies of the 1959 Missile Handbook are still available from the Association of Missile & Rocket Industries, 1079 National Press Bldg., Washington, D. C.

Updated as of July, the handbooks are priced at $1.50 per copy.

FACILITIES

Aluminum Co. of America is installing a 5,200-ton capacity extrusion press at its Vernon, Calif. works. This will be used to extrude aluminum alloy shapes of up to 34 sq. in. cross sectional area.

Tinsley Laboratories, Berkeley, Calif. has been appointed distributors for Corning glass color filters.

California Eastern Aviation Inc. has acquired **Lund Aviation.**

Chance Vought has revised its structure to include five divisions: astronautics, aeronautics, electronics, range systems and research.

$5-million production facilities have been completed at **Allegany Ballistics Laboratory,** Cumberland, Md. for development of Polaris second stage motors.

The **145-foot static test tower** for the 1,500,000-lb-thrust Saturn booster will reportedly be ready for use this month. Saturn testing is due this December.

U. S. Chemical Milling Corp. has acquired **Darco Industries** and the Aircraft Div. of **H & B American Machine Co.**

Heat treatment furnace slated to operate at **General Electric's Flight Propulsion Laboratory Dept.,** Evandale, O., will enable rocket cases up to 30 ft. long and 10 ft. in. diam. to be processed.

Acoustica Associates has opened a new ultrasonic plant in Plainview, L. I.

Prat - Daniel Corp., Aerotec Corp., The Thermix Corp. and **The Aerotherm Corp.** have merged.

A 100-ft.-long modulator will be installed in 50,000 sq. ft. wing to be added to **Raytheon's new Spencer Laboratory** in Burlington Mass., next year. It will test and develop Amplitrons having power in the megawatt range, and reportedly great potential for antimissile defense.

Electro - Mechanical Research, Sarasota, Fla. will reportedly purchase all the assets of **Applied Science Corp.,** Princeton, N. J.

Republic Aviation will install a 30-ton space-envioronment chamber in its astronautics research center early next year.

Boeing Airplane Co. plans to construct a $2,250,000 building near Seattle to house its Scientific Research Laboratories.

Marquardt Corp. plans a 60,000 sq. ft. structure for its Power Systems Group in Van Nuys.

Dow Chemical has formed a new division, known as The Dow Metal Products Co. for fabricating magnesium, aluminum and other metals.

Du Pont plans to complete its metallurgical research center in Baltimore in about a year. Equipment here will be used to develop high-temperature metals.

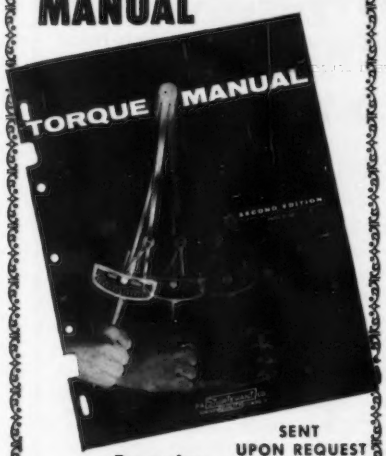
Aerojet-General plans to begin constructing six-million-pound-thrust rocket test stand at Edwards Air Force Base, Calif. by the end of this year.

Westinghouse Electric Corp. will establish an astronuclear laboratory for development of nuclear energy for outer space. Located in Pittsburgh, it will be part of a new atomic power division.

ITT's Advanced Development laboratory, San Fernando, Calif., has established a research and pilot production unit to make microwave electron tubes and conduct basic electron tube research.

This month **Thompson Ramo Wooldridge Inc.** begins building a $2-million plant in Anaheim, Calif. for the West Coast Div. of its Tapco Group.

"TORQUE WRENCH" MANUAL



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CONTRACT AWARDS • • •

Aerojet-General Corp. received an undisclosed multimillion dollar contract from Douglas Aircraft to produce 15 liquid-powered second-stage units for NASA's **Delta** space program. Deliveries will extend over the next two years. Aerojet-General itself awarded the Lycoming Div. of Avco Corp. $6-million in contracts for **Minuteman** second and third stage rocket changers, and chambers for **Polaris.**

ARPA announced that a modified first stage of Martin's Titan (Aerojet-General propulsion) will form the second stage of the **Saturn** space vehicle. The third stage will be the new **Centaur** rocket (being developed by Pratt & Whitney and Convair).

ARGMA awarded Convair-Pomona $6-million to develop **Red-Eye,** new SAM shoulder-fired missile system. The Navy awarded Reaction Motors $3.5 millon for production of **Guardian II** pre-packaged rocket engine. Other missile contracts: $3,614,415 from ARPA to Philco Corp. for communications package for **Project Courier** delayed relay communications satellite; $4,046,119 to I T & T for Courier's ground-based communications; $1,283,740 to Radiation, Inc., for the ground antennas.

Minneapolis Honeywell Regulator Co. will develop and produce the inertial guidance system for **Centaur** under a $5.4-million contract from Convair.

Aircraft contracts included: $8-million to General Electric's Small Aircraft Engine Dept. for T58 turboshaft helicopter engines, $25-million to the Department for J85 jet aircraft and missile engines; $7,591,218 additional funds to the

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For details about these positions please write: Mr. L. J. Stevenson, Engineering Personnel, North American Aviation, Inc., Los Angeles 45, California.

THE LOS ANGELES DIVISION OF
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Lycoming Div., Avco Corp. for flight test and overhaul of the **T53** turbo-jet. $23.5-million to Pratt & Whitney to further develop **J-52** turbo-jet.

Orendo Engines Ltd. of Malton, Ont., will build the **GE J-79** engine for the F-104 E fighters slated for NATO. Contract: $92-million. The airframe contract will total about $164-million.

The Air Force cancelled work on the Convair **B-58B** strategic bomber and its General Electric **J79-GE-9** engine.

Waltham Precision Instrument Co. will develop and produce a scheduling device setting off 13 activities, including re-entry, for **Project Mercury.**

Avco Corp. received a $73,360,000 Air Force contract for R & D of an "advanced design" re-entry **nose cone for Titan.**

Cal Tech and Columbia each received $130,000 to construct a **seismograph to be used on the moon.** Other contracts: MIT—$100,000 to design and build a prototype instrument for measuring the **density of plasma between earth and moon;** GE—$390,000 contract for an eight months' study of a **plug-nozzle engine;** RCA—a major subcontract from Boeing Airplane Co. for making it responsible for the command and support information networks of the **Minuteman** launch-control system.

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TERRA-SCOPE

The 22-ft-long leading edge for rotary wing of Kaman Aircraft's HU2K jet utility helicopter is produced from an extruded aluminum hollow-shaped piece about 10 in. across, 4 in. high, 26 in. long. A specially-designed automatic Lapointe broaching machine finishes the inside to a mirror-like finish, process taking about 30 to 35 broaches. Advantages include higher fatigue resistance, uniform size inside allowing easier mass balancing and machining, and weight-saving of about five per cent on the spar. HU2K, going through tie-down and flight test, has fiberglass trailing edge on rotor. Original design utilizes few off-the-shelf items.

•

Delegates from the UAW and IAM have drafted a single set of demands on wages, pensions, etc. to be presented next year to aircraft and missile firms and their suppliers.

•

NASA memorandum 5-10-59L is a review of aircraft altitude errors due to pressure installations at fuselage nose, wing tip and vertical fins. Studies at the Langley Research Center showed that these errors due to static-pressure source are large, especially at transonic speeds for typical pressure-sensor installations. Memo says such errors can be aerodynamically compensated by using a comparatively simple form of static-pressure tube installed on a relatively short nose boom.

Reliability requirements for missile and satellite relays would be tightened under industry-wide standard test methods which may be proposed by the American Standards Asso.

•

Lycoming Div., Avco Corp. has refined three dimensional milling techniques to reduce forgings for second and third stage fuel chambers and heads for the Minuteman. It is adding two new Cincinnati template-controlled milling machines in addition to the three already operating. Lycoming is hydrospinning low angle cones 48 in. in diam, 40 in. long. Aluminum blanks are spun down to thin-walled cones .090 and .165 in. thick.

DESIGNATION	APPLICATION	STATUS	RATING	FEATURES
J-79	F-104, B-58, F4H-1, A3J, F11F-1F	Production	More than 15,000 lb. thrust	Has 90% of all U.S. Mach 2 flight time
TF-35	Near sonic military transports and logistics aircraft	Test and evaluation	More than 15,000 lb. thrust	Successfully completed 1,000 hr. test
J-93	F-108, B-70	Design and development	Mach 3+	Will cruise at altitudes in excess of 70,000 ft.
X-211	Nuclear powered aircraft	Classified	Classified	Classified
CJ-805-3	Convair 880	Test and evaluation	15,000 lb. thrust	Many hot parts have run 2,500 hrs., are reinstalled and are running additional tests
CJ-805-23	Convair 600	Test and evaluation	CJ-805 with aft fan	7 engines running, with one completing 600 hrs. and two, 150 hrs.
Rocket Motor Casings	Solid propellant missiles and rockets	Research, design, development and production	N/A	Hydroforming techniques have led to increased strength/reduced weight
Rocket Motor Nozzles	Solid propellant missiles and rockets	Research, design, development and production	N/A	Revolutionary spray-on tungsten technique has been developed
Liquid Rocket Engine	Second stage for Vega vehicle	Design and development	N/A	Adaptation of Vanguard engine for space research
Ion and Plasma Propulsion	Manned space vehicles	Applied research	Undetermined	New theories have been developed applicable to manned space flight
VTOL Project	Fixed wing aircraft	Design and development	N/A	New technique gives fixed wing aircraft capability for vertical takeoff and landing
Boost Turbojet	Will be used to launch satellites and space vehicles	Feasibility studies and research	N/A	Recoverable first-stage launching powerplant

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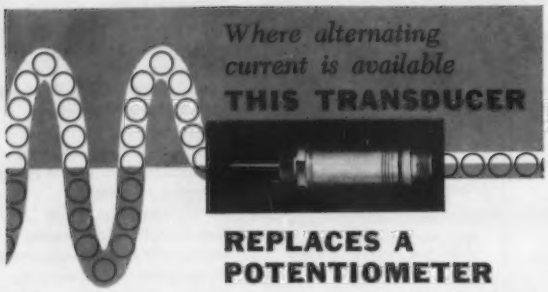

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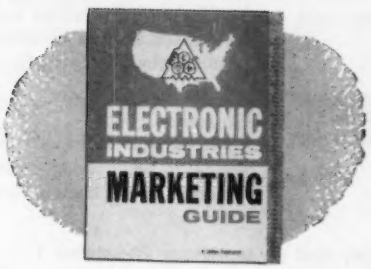

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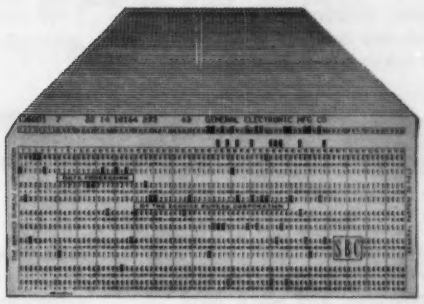

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Number of Electronic Engineers
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conference on physical chemistry
in aerodynamic and space flight
OSR (air force), MSVD (general elec.)
university of pennsylvania, phila., pa.

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university of california, berkeley, calif.

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september 7-13
1959 Farnborough flying display and
exhibition
society of british aircraft constructors
farnborough, england

september 9-11
sixth midwestern conference on fluid
and solid mechanics
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sciences, ONR, NSF
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september 14-16
14th midwest quality control confer-
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american society for quality control
sheraton hotel, french lick, ind.

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September 16-17
western regional meeting on frontiers
on science and engineering
institute of the aeronautical sciences
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september 20-25
14th annual conference and exhibit
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